POWER

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"CON," said Mac, "I once knew a man what jumped 50 feet!"

"Mac," responded Con, "I had a brother out in Africa who, after bein' chased ten miles by cannibals, came to a river a mile wide. He never stopped; he jumped over it. How's that for a jump?"

"That's a pretty fair jump," said Mac, "but look at the start he had!"

To get a good start makes most of the difference. Endowed with ordinary intelligence, well-formed habits of thoroughness and neatness, and an honest desire to be something, a young man has a foundation on which he can erect a solid, lasting structure. No obstacle that besets the path to success is too great to be overcome if he is quick to grasp the opportunity and press forward.

Sure it's hard, this getting started! It means plowing down into the dirt and drudgery that so often discourage the beginner unless he can detect the faint ray of light and hope that rims the cloud. But it also means to the observing superior that the young man armed with the broom or cotton waste is on the alert for the dust and the grease spots; that this young helper does not feel above his position and is the raw material that in time will be molded into the skilled mechanic—in a word, he is making a good start.

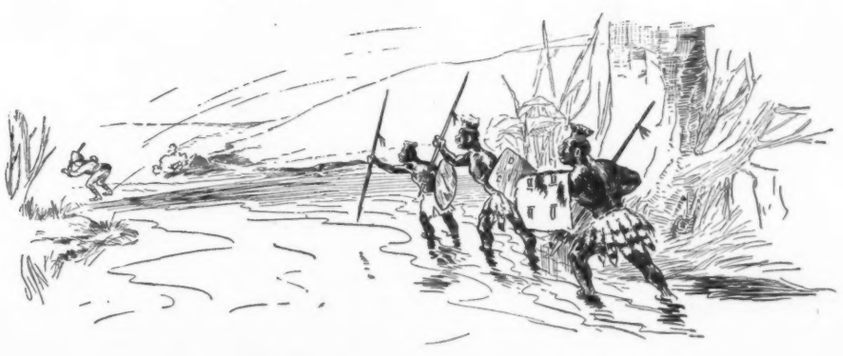
These good old United States have hundreds of men at the head of the large industries whose early circumstances denied them the advantages of what is called the higher education. But they were keen to reason that many of the men at the top once started in very humble fashion, and that it was only by patient industry, perseverance and a hustling desire to advance themselves that they climbed the high rung of the ladder.

In his youth the young man finds it far easier to get ahead than do the older ones, who are often handicapped by family obligations and who cannot afford to make a fresh start. Then, too, the young man's mind will more readily grasp new ideas and assimilate them; his perception is more acute and his mind is more retentive.

Often the young fellow grows fainthearted because he entertains the mistaken notion that the old man does not want the youth to rise from his present position and will discourage any attempt on his part to advance himself.

The skill and good will of the subordinates are largely necessary to the successful operation of any plant, and every far-seeing and clear-headed chief knows that his proper administration is dependent to a great extent on the coöperation of the men under him.

Start right, for there is a big demand in the industrial field at the present time for skilled mechanics who, with a little executive training, progressive ideas and energetic methods, may occupy positions of trust and responsibility.



Today is the time, now is the hour; go to it!

An Interesting Isolated Power Plant

By Warren O. Rogers

This plant is being operated so economically that the inducements offered by the central station have not made any impression upon the management. The plant contains ordinary machinery and can be duplicated for $15,000. Many homemade devices have been devised which assist in obtaining high economy.

Several weeks ago an article was published describing the record system kept by Asa P. Hyde, chief engineer of the Security Mutual Life Insurance building, Binghamton, N. Y., of which Fredrick W. Jenkins is president. Central-station representatives have repeatedly attempted to obtain a foothold in Mr. Hyde's plant without success. There is nothing out of the ordinary in the equipment of this power plant, which is located in the subbasement of a ten-story office building; views of the engine room are shown in Fig. 1.

The power plant in this building can be duplicated for $15,000 and a description of it will undoubtedly be of interest and value to isolated-plant engineers. Allowing 10 per cent. of the cost price for interest and depreciation, the fixed charges are less than 0.045 cent and the total cost is 1¼ cents per kilowatt-hour. Were the engineers credited with work done about the building the cost per kilowatt-hour would be slightly decreased. No. 1 buckwheat coal is burned, costing $3 per ton, delivered to the plant.

One reason why this plant is being operated so satisfactorily is because the company is satisfied to leave the entire care, management and purchasing of supplies and equipment to the chief engineer. All supplies are charged up to the departments to which they are delivered.

Another reason for economical operation is the care taken of the apparatus in the plant. Although it is seven years old, the machinery is as good now as when first installed, and there has been no shutdown or trouble during this time, although the plant is run 24 hours a day. This showing is due to good management and the men all pulling together.

Every avenue for loss has been closed, as much as is possible. The boilers and the steam and hot-water pipes are protected by a covering of extra-heavy thickness, many of the pipes, etc., having had additional coverings since the original was put on. Even the pipe flanges and unions are protected.

All of the steam-pump cylinders are covered and in the case of the hot-water pumps both water and steam ends are covered. These covers are made in two sections and are removable where possible.

All of the steam-pump cylinders are used over again, and a homemade muffler is used through which the exhaust steam from the pumps and engines passes. This muffler contains a nest of baffle plates which act as oil extractors.

On the pipe line outside of the muffler is an oil eliminator. All returns and drips are run to an open heater which maintains a temperature of from 210 to 212 degrees, generally the latter.

The return system is so efficient that only enough makeup water is required to keep the water from becoming too pure.

Economical operation is also due to the manner in which the fuel is handled. A daily record is kept of the day and night coal consumption, the amount of ashes obtained, water evaporated, which is measured by a meter, and the total output of the plant in electrical energy. If the coal is not up to the standard it is rejected.

These methods of operation enable the plant to be run at the low cost of $1.06 per kilowatt-hour, which figure was the average for one month, all operating expenses being charged up to the generators.

The mechanical equipment consists of two 175-horsepower return-tubular boilers, hand fired and operated under natural draft that is controlled by a damper regulator. The combustion is carried back over the top in a return flue. The boilers are set in a room that is separated from the engine room by a brick wall. Large windows in the portion opposite the firing floor permit the night engineer, who does his own firing, to have a view of the engine room while engaged in the boiler room and *vice versa*. The steam pressure carried is 100 pounds per square inch.

In the engine room there are three high-speed engines direct coupled to direct-current generators. There is one 90-horsepower Ridgway engine, one 60-horsepower and one 200-horsepower Skinner engine. The first two are direct coupled to a 40- and 60-kilowatt generator respectively. The large 16½x

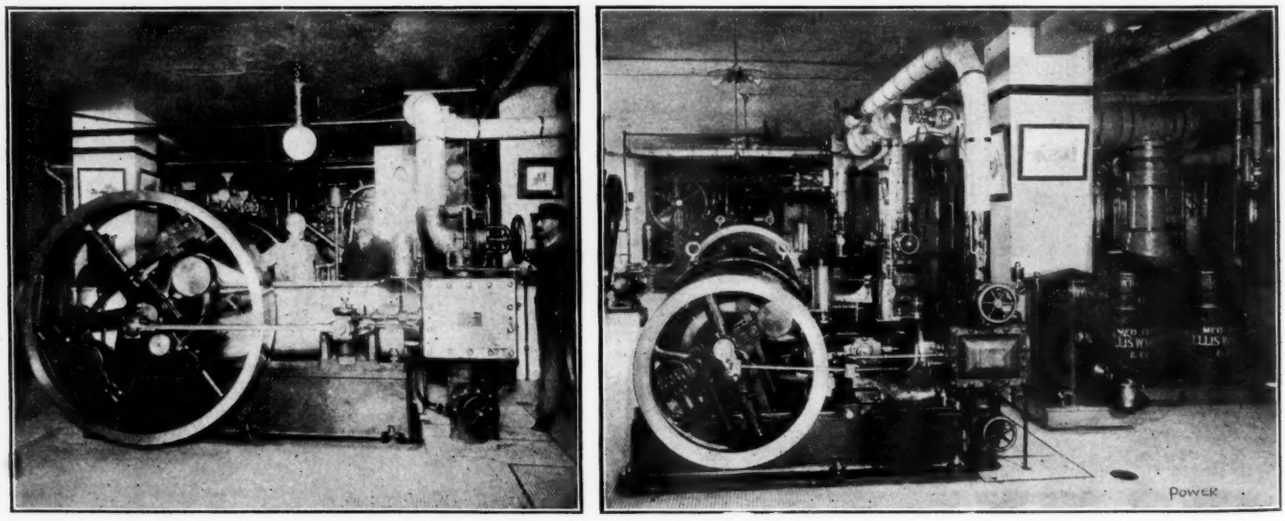


FIG. 1. TWO VIEWS OF THE ENGINE ROOM OF THE SECURITY MUTUAL LIFE INSURANCE BUILDING

16-inch Skinner engine is direct coupled to a 125-kilowatt General Electric generator. Owing to the nature of the load, the large engine is run the greater part of the time. This load carries lights and motors, the latter being used throughout the building; also the load of the Carnegie library, next door. The two principal 40-horsepower motors drive two Goulds triple-plunger power pumps, which are used for elevator service.

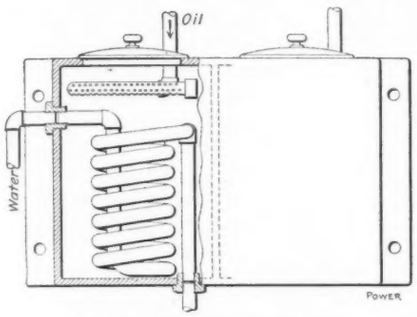


FIG. 2. OIL-COOLING COIL

Both elevator pumps have 8x10-inch plungers and are belt driven, each pump taking its water from a return tank and forcing it into a pressure tank against a pressure of 170 pounds per square inch.

The plant is full of useful, homemade kinks, one of which is found in the oil tank on the Skinner engine, shown in Fig. 2, and is Mr. Hyde's idea. This oil tank has a ⅜-inch perforated inlet pipe, capped at the end, through which flows the oil from the bearings. There is also a coil of ⅜-inch piping arranged as shown, through which cold water is forced at the bottom and is discharged at the top outlet. This arrangement cools the oil coming from the bearing at a temperature from 90 to 75 degrees Fahrenheit after it has passed over the water coil.

There are two Standard plunger hydraulic elevators. Considerable trouble was had at first with the men operating these elevators, due mostly to running past a landing and throwing the controlling lever over suddenly in order to lower the car to the proper level. There is a pressure of 30 pounds to the square inch against the plunger when the car is stationary at the landing and 120 to 170 pounds per square inch when the car is going up. This practice needlessly consumed electrical energy, and the elevator men operated their cars about as they chose, when no one was looking.

When the gage board shown in Fig. 3 was put up in the engine room, this practice was stopped as the engineers on watch could see just what the elevator operators were doing.

Each elevator is connected to a telltale which indicates the floor at which the car is at rest. A counter records the number of full trips made by the car to which it is attached; no partial trips are allowed. A gage designates the pressure on the plunger of the elevator and another gage shows the pressure carried on the service tank.

The floor gage, shown in detail at the left of the gage board, consists of a graduated face over which a movable piece travels. A weight attached to the movable piece causes the indicator to descend when the car is on a down trip. The cord attached to this indicator is fastened to a part of the car mechanism where the reduction of movement allows the telltale on the gage to move the length of the gage board while the car is making one full upward or downward trip.

This gage shows whether an operator is holding his car at a landing longer than is necessary, or it is run by its landing and dropped again. The pressure gage shows whether the operator is properly running the car; if the pressure jumps the operator is "plugging" the car. If an operator does not obey orders he is warned, and if he persists in disobeying orders he is discharged. The motors and belt-driven pumps are automatically controlled, starting when the water pressure has fallen a predetermined amount and stopping at the high-pressure limit.

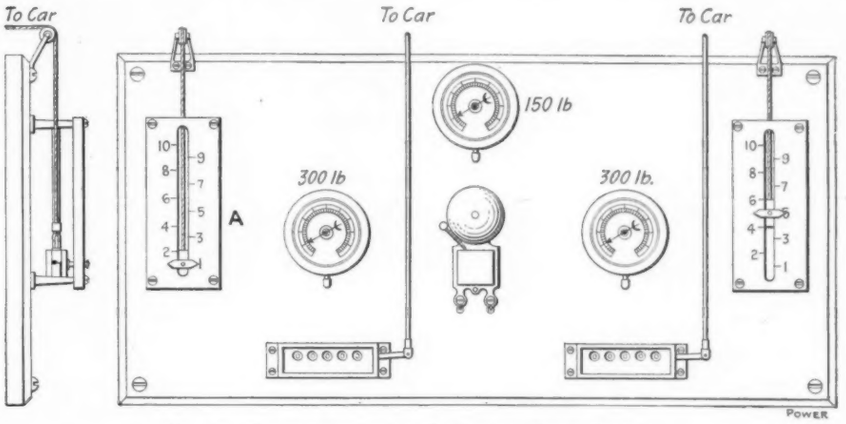


FIG. 3. DIAGRAM OF THE ELEVATOR GAGE BOARD

One pump starts first and the second acts as a booster.

Fig. 4 illustrates the pump installation at the end of the engine room. The largest pump is a tandem duplex steam-elevator pump, but is held in reserve as the electrically driven power pumps are used for general service, and in this plant can be operated more cheaply than the steam pump. This fact was determined by practical tests. The compound pump was tested for two days and the electrically driven duplex pump for two days, the number of elevator trips being practically the same. The electrically operated pump showed a saving of 4581

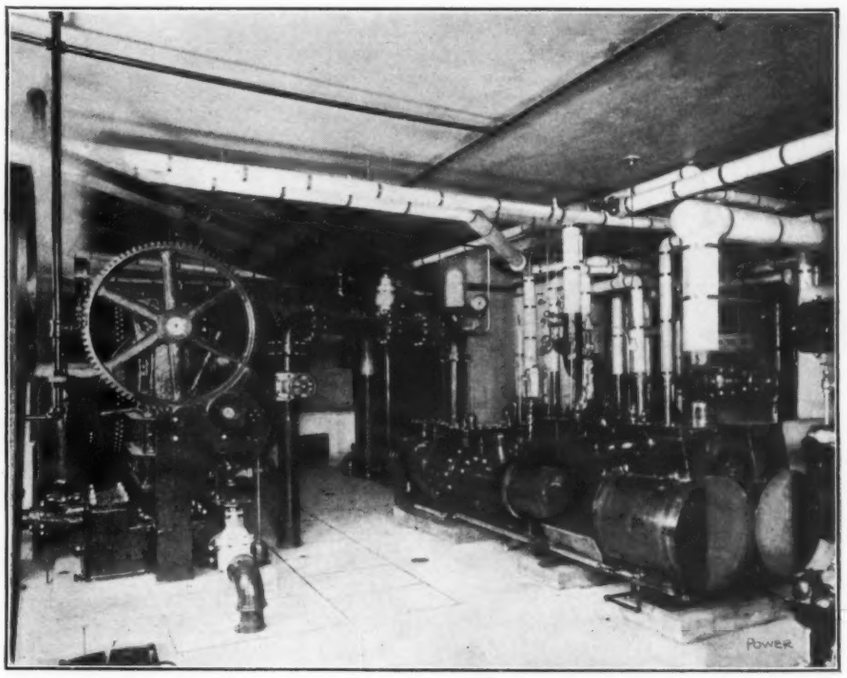


FIG. 4. GENERAL VIEW OF THE ELEVATOR PUMPS

pounds of coal in the two days, and the number of trips during the two tests with the compound pump were 923 and 841; 822 and 879 trips were made with the power pumps. The daily records always check up in favor of the electric-driven triplex pump; aside from this the maintenance is much less.

Under the engine-room floor there is a sump pit in which drips from the pumps and engines are collected. A small duplex pump, which takes care of the sump water, is set directly over the sump pit and in order that the engineer on watch may know when anything might be wrong, as the pump failing to start up, an alarm system has been devised. A float in the sump is connected to a rocker arm *A*, Fig. 5, which is attached to the base of the pump. From this rocker arm a rod *B* extends up to a small switchboard placed above the pump. This rod is attached to a cross arm *C* which is pivoted in the center. The switch blades *D* and *E* are attached to each end of the arm *C* by means of a link. The action of the switch *D* is positive, but the switch *E* is opened by the operator, although it is closed by the action of the float.

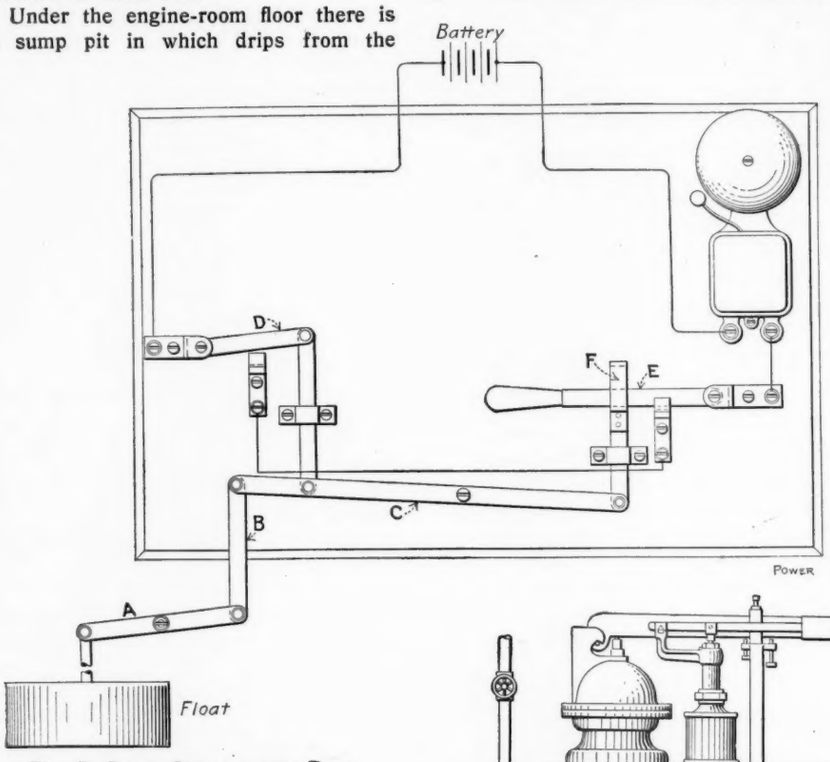


FIG. 5, SUMP SWITCH AND BELL ARRANGEMENT

When the sump pit fills with water the float rises, and the rod *B* is moved in a downward direction. This closes the switch *D*, but the switch *E* will remain closed, because a slot in the guide *F* permits an upward movement without its moving the switch blade *E*.

When the switch *D* is thrown by the action of the float the circuit is closed and the bell rings. The engineer then knows that there is trouble with the pump. The ringing of the bell is stopped by throwing open the switch *A*, which is made possible by the slot in the link *F*.

As the water in the sump lowers the float falls and opens the switch *D* and closes the switch *E* which, owing to the length of the slot in the link *F*, does not make contact with its terminal until the switch *D* has opened. This arrangement automatically sets the switch for the next sump full of water and stops the bell from ringing after the engineer has had his attention called to the sump.

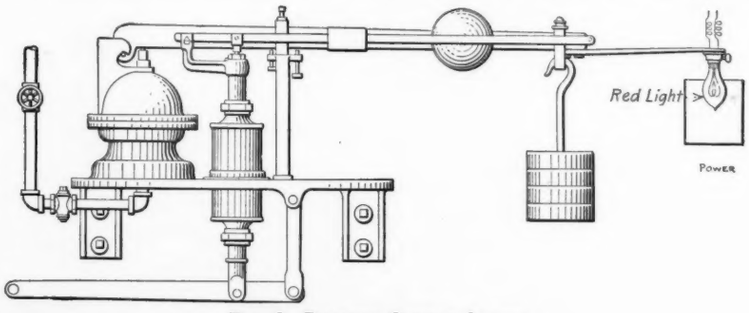


FIG. 6. DAMPER SIGNAL LIGHT

A convenient arrangement for the night engineer is a red light attached to the arm of the damper regulator. When the damper is shut the light drops into a can and is not visible in the engine or boiler room. When the damper is wide open the light shows and the engineer knows that the fire requires attention. The arrangement is shown in Fig. 6 with the damper regulator in its normal position when but a portion of the red light shows.

The hot- and cold-water pumps are motor driven; the water is pumped into tanks under 90 pounds pressure. When it drops to, say, 87 pounds the motor is automatically started by the reduction of water in the tank which acts on a pressure gage. This gage has a contact point which closes the circuit through a magnet which acts on a switch. As soon as the pressure has reached 90 pounds the circuit is broken and the switch is opened. A small steam pump is held as an emergency unit.

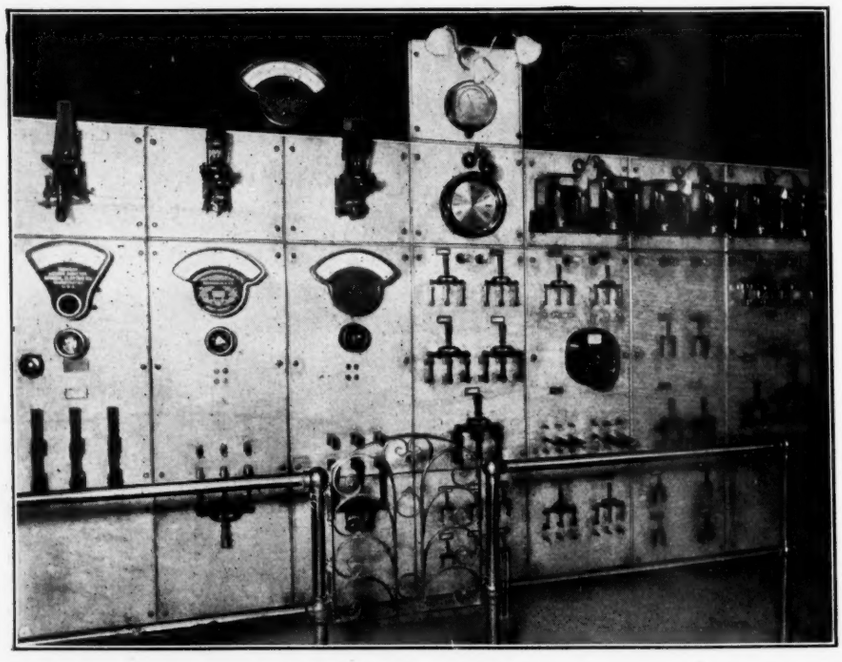


FIG. 8. MAIN SWITCHBOARD

An auxiliary exhaust-steam hot-water heater is shown in Fig. 7. It contains two sets of coils, one of 3-inch brass pipe, through which either live steam or exhaust steam from the heating system

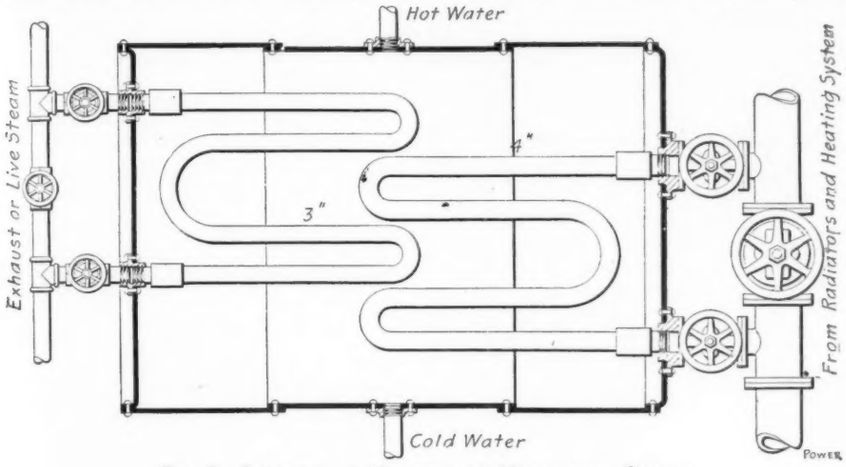


FIG. 7. DIAGRAM OF HEATER FOR HOT-WATER SYSTEM

and pumps can pass, and a set of 4-inch brass coils which are connected to the Webster vacuum return system. The supply of exhaust steam is controlled by a thermostatic valve. Cold water enters at the bottom of the heater and when heated by the coils is pumped to the hot-water system.

Although there are a good many pumps, etc., they are so arranged as to give a neat, orderly appearance to the engine room, a plan view of which is shown in Fig. 9.

A view of the switchboard is shown in Fig. 8. It is made of seven panels of Vermont marble, three of which are for the generators, and two each for the motor and lighting circuits.

Three men are on duty during the day, and one man during the night run. The shift hours are from 6 a.m. to 6 p.m. and 6 p.m. to 6 a.m.

Renaissance of the Naval Reciprocating Engine

The Scientific American recently published an editorial, which is of such an interesting character that we are reproducing it in part.

When it was recently announced that the Navy Department had decided to return to the reciprocating engine as a drive for battleships, we expressed astonishment that this should be done at a time when every other naval power was using the steam turbine exclusively. That the action of the department was based upon fact and sound reasoning, however, is shown by the comparative steaming results obtained from two sister ships, the "North Dakota," which is equipped with turbine engines, and the "Delaware," driven by standard reciprocating engines.

An opportunity for comparison of coal consumption under identical conditions was recently afforded when the two ships were steaming with the North Atlantic fleet, the "North Dakota" in position directly astern of the "Delaware." We are officially informed that average results for 10 days show that using coal from the same collier, employing the same auxiliary engines, and steaming at the same speed, of 12 knots, under identical conditions of wind and weather, the "North Dakota" consumed 43 per cent. more coal than the "Delaware."

than full speed the turbine consumption becomes relatively larger and at cruising speed considerably so. But it has taken such a test as this, made under seagoing conditions, to show just how extravagant is the coal consumption of the turbine under cruising conditions.

What makes the record of the "Delaware" so very significant is the fact that she recently carried out her annual full-speed trials, at the close of some 19,000 miles of all but continuous steaming, and under conditions which show her reciprocating engines to be remarkably reliable, and capable without any preliminary preparation of equaling and even surpassing the results obtained during the original acceptance trials.

After the ship had just concluded some 19,000 miles of steaming without undergoing any dock repair or machinery overhauling whatsoever. Nevertheless, the "Delaware," steaming for four consecutive hours at full power, made an average of 21.86 knots, which is nearly a third of a knot more than the 21.56 knots she made on her official trials. But she did even better than that; for on the 24-hour continuous run at full power she averaged 21.32 knots, and this in spite of the fact that she was burning coal only,

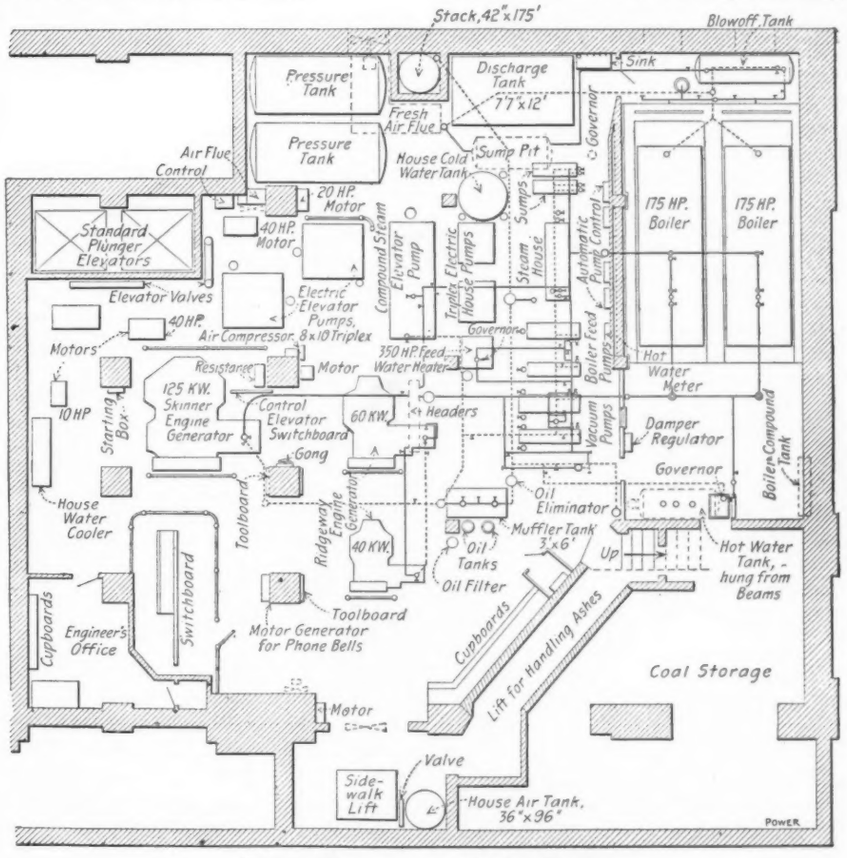


FIG. 9. PLAN OF THE POWER PLANT

It has always been understood that the turbine showed its best efficiency when it was being driven at full speed, under which conditions its coal consumption is as good if not better than that of the reciprocating engine. At anything less

had her regular watch in the fire rooms and was cleaning fires as usual. A further tribute to her engine-room efficiency is found in the fact that the ship has steamed 30,000 miles without any adjustment of her engines.

Equal Work in Compound Engine

By F. R. Low

What should be the receiver pressure in order that the work may be equally distributed between the cylinders of a compound engine, initial and back pressure, cylinder ratio and point of cutoff in the high pressure being known?

This is a pet question with a Massachusetts examiner. The article shows how it may be solved. The formulas are simpler than they look and require a knowledge of only simple arithmetic. Incidentally the article explains the process of figuring mean effective pressures.

A Massachuetts inspector has a pet question which he asks of candidates for first-class licenses. We have not the actual wording, but as given to us it is something like this.

With a given initial pressure and point of cutoff in the high-pressure cylinder and a given back pressure in the low, what should be the receiver pressure in order that the work may be equally divided between two cylinders having a known ratio?

Without the introduction of the back pressure, this might be understood as referring to the gross amount of work done in each cylinder, that is, to the work done by the mean forward pressure, in which case its solution would be easy.

To make this perfectly clear, the steam does an amount of work proportional to the area $A\,B\,C\,D\,E$ in Fig. 1, but an amount of this work proportional to the area $F\,G\,D\,E$ is required to overcome the back pressure.

If the line $A\,B$ be taken as the unit of volume and the line $A\,E$ is the unit of pressure, the area $A\,B\,H\,E$ under the admission line will also be unity and the area $B\,C\,D\,H$ under the expansion line will be the hyperbolic logarithm of the total length of the diagram $E\,D$ measured in the units $A\,B$. The length $E\,D$ represents the final volume of the steam, the length $A\,B$ the initial volume and the quotient of the final by the initial volume is the "ratio of expansion."

In Fig. 1, $E\,D$ is four times as long as $A\,B$. One volume of steam is expanded to 4 volumes. The ratio of expansion is 4. The hyperbolic logarithm* of 4 is 1.3863, so that the whole area $A\,C\,D\,E$ would be proportional to $1 + 1.3863 = 2.3863$ for a ratio of expansion of 4, or of $1 + log.e\ r$ for any other ratio r of expansion ($log.e$ is the usual expression for hyperbolic logarithm).†

To find the mean or average of the varying pressure $A\,B\,C$ it is necessary only to divide the area $A\,B\,C\,D\,E$ by its length.

The area is $1 + log.e\ r$ and the length is r. The mean hight is then

$$\frac{1 + log.e\ r}{r}$$

Applying this to Fig. 1:

$$\frac{1 + 1.3863}{4} = 0.5966$$

and the mean or average pressure is represented by the line $I\,J$, at 0.5966 of the hight of the diagram.

Fig. 2 is a combined diagram where the steam is expanded from B to C in the first cylinder and to D in the second. This latter expansion may be from C to D in the larger cylinder if the high-pressure diagram ends in a point as at C and the back pressure is equal to the terminal, or there may be free expansion in the receiver as from C to M, in which case $L\,M$ would be the back pressure in the high- and the initial pressure in the low-pressure cylinder.

In any case, since the product of the pressure and volume is constant the areas of the rectangles $A\,B\,P\,J$, $K\,C\,H\,J$ and $L\,M\,N\,J$ are equal and may each be represented by unity.

The gross work done by the high-pressure cylinder is $A\,B\,C\,H\,J$ and is proportional to $1 + log.e\ r$, if r represents the ratio of expansion in that cylinder.

The gross work done by the low-pressure cylinder is $K\,C\,D\,F\,J$ or $L\,M\,D\,F\,J$. The area under the admission line is the constant product of pressure and volume and may be represented by 1, as above explained. The area under the expansion line is to the area under the admission line as the hyperbolic logarithm of the ratio of expansion is to 1. Then the area $L\,M\,D\,F\,J$, for instance, would be proportional to 1 (the area $L\,M\,N\,J$) plus the area $M\,D\,F\,N$, which latter would be proportional to the hyperbolic logarithm of the ratio of expansion in the low-pressure cylinder, which call r_2.

Then the gross work in the high-pressure cylinder is

$$1 + log.e\ r_1$$

and that in the low-pressure

$$1 + log.e\ r_2$$

and it is apparent that for the gross works to be equal the ratios of expansion in both cylinders must be the same.

It is possible that this is the answer that the inspector has in mind, notwithstanding his giving of the back pressure.

The total ratio of expansion is the product of the ratio of expansion in the high-pressure cylinder and the cylinder ratio, both of which are given.

The terminal pressure in the low-pressure cylinder will be the initial absolute divided by the total ratio of expansion, and the initial pressure in the low (that is, the receiver pressure sought) will be the terminal pressure multiplied by the ratio of expansion in that cylinder, which is the same as that given for the high-pressure cylinder.

When, however, the net work, the difference between that done by the mean forward pressure and that required to overcome the back pressure (the work represented by the indicator diagram), is to be made equal, the problem becomes more complicated.

For the case where there is no drop in the receiver, that is, where the expansion in the high-pressure cylinder is carried to the receiver pressure and the line $K\,C$ represents the back pressure in the high and the initial pressure in the low, the receiver pressure is fixed. It will be the initial absolute pressure divided by the ratio of expansion in the high; but only with one cylinder ratio will the net works be equal.

The net work in the high-pressure cylinder is represented by

$$\begin{aligned} &\text{the area } A\,B\,P\,J = 1 \\ &\text{plus the area } B\,C\,H\,P = log.e\,r_1 \\ &\text{minus } \begin{cases} \text{the area } K\,C\,H\,J = 1 \\ \text{or} \\ \text{the area } L\,M\,N\,J = 1 \end{cases} \end{aligned}$$

$$1 + log.e\ r - 1 = log.e\ r$$

or is simply proportional to the hyperbolic logarithm of the ratio of expansion in that cylinder.

The net work of the whole diagram is represented by

$$\begin{aligned} &\text{the area } A\,B\,P\,J = 1 \\ &\text{plus the area } B\,D\,F\,P = log.e\,R \\ &\text{minus the area } I\,E\,F\,J = \frac{p_5}{p_1}\,R \end{aligned}$$

Since we have taken $A\,J$ as the initial pressure p_1, the distance $I\,J = p_5$ can be only such part of unity as the p_5 is of p_1. The hight $I\,J$ of the back-pressure area

*Tables of hyperbolic logarithms may be found in all of the better class of engineers' reference books.

†This is true only when the pressure varies inversely as the volume, twice the volume half the pressure, etc., the product of the pressure and volume remaining constant, in which case the curve is a rectilinear hyperbola. The expansion line of an ordinary indicator diagram follows this law more or less closely.

is represented then by the product of $\frac{p_5}{p_1}$ and its length R, the total ratio of expansion, which will be the length of the line $I\,E$ measured with $A\,B$, the initial volume, as unity.

The net work of the whole diagram is then proportional to

$$1 + log.e\ R - \frac{p_5}{p_1} R$$

If the work is to be equally divided this is twice what each cylinder will do; and since the work done by the high is

$$log.e\ r_1$$

$$2\ log.e\ r_1 = 1 + log.e\ R - \frac{p_5}{p_1} R$$

$$2\ log.e\ r_1 - 1 = log.e\ R - \frac{p_5}{p_1} R \quad (1)$$

This allows a solution in a rather indirect way, as may be best exemplified by trying an example.

An engine has 120 pounds absolute initial pressure, four expansions in the high-pressure cylinder and 2 pounds absolute back pressure. What must be the cylinder ratio and number of expansions in the low-pressure cylinder in order that the net work may be equally distributed?

$$p_1 = 120 \qquad r_1 = 4$$

$$p_5 = 2 \quad log.e\ 4 = 1.3863$$

Substituting these figures in formula 1 we have

$$2 \times 1.3683 - 1 = R - \frac{2}{120} R$$

$$1.7726 = log.e\ R - \frac{1}{60} R$$

The hyperbolic logarithm of the total ratio of expansion R is enough greater than 1.7726 to allow 1/60 of R to be taken from it and have 1.7726 left. Take the table of hyperbolic logarithms and make a trial. For a ratio of 6.69 the logarithm is 1.9006.

$$\frac{1}{60} \text{ of } 6.69 = 0.1115$$

$$1.9006 - 0.1115 = 1.7881$$

This is too large.

For the ratio 6.36 the logarithm is 1.8500.

$$\frac{1}{60} \text{ of } 6.36 = 1.060$$

$$1.8500 - 0.1060 = 1.7440$$

This is too small.

The true value lies somewhere between 6.36 and 6.69 and narrowing down the discrepancy by successive trial I find 1.8822, corresponding to the ratio 6.568, to fulfil the condition.

I have prepared the accompanying table to facilitate the calculation. The first column in the lower portion of the table is the ratio of the back pressure to the initial $\frac{p_5}{p_1}$. In this case it is $\frac{2}{120} = 0.0167$. The nearest value to this in the first column is 0.015. Follow along this line of the table horizontally until the number most nearly corresponding to the given number (that is, twice the hyperbolic logarithm of the ratio of expansion in the high-pressure cylinder minus one, $2\ log.e\ r - 1$), in this case 1.7726. This is the 1.7743 in the column for 6.5 expansions, showing that this total ratio 6.5 is nearly right for the given conditions.

$$\frac{1}{60} \text{ of } 6.568 = 0.1094$$

and

$$1.8822 - 0.1094 = 1.7738$$

which is as near the 1.7726 as can be gotten without carrying the ratio to another decimal place.

Proof: With 120 pounds initial and 4 expansions the terminal pressure in the high-pressure cylinder is

$$120 \div 4 = 30 \textit{ pounds}$$

The mean effective pressure in that cylinder will be

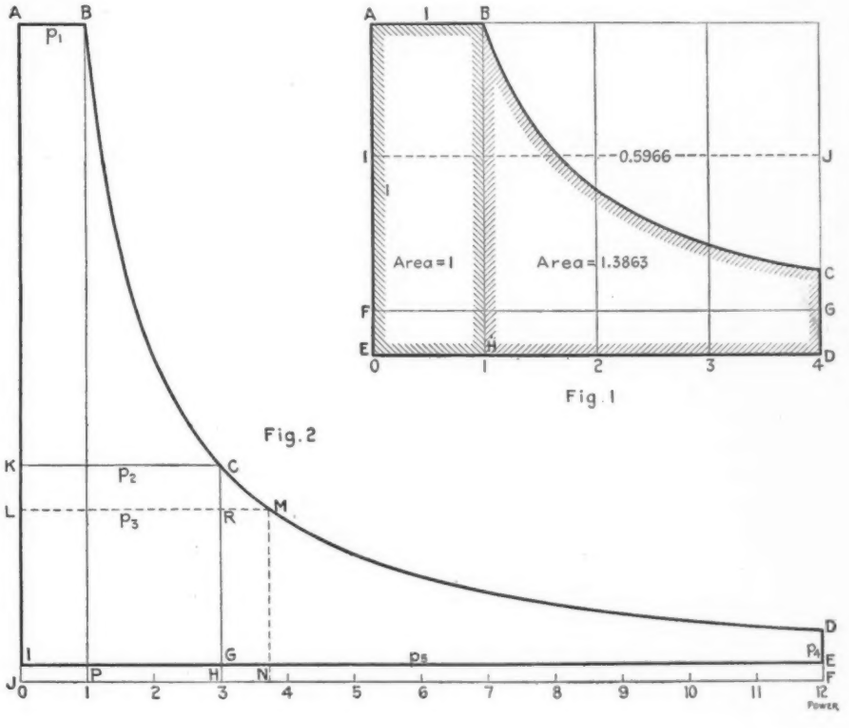


Fig. 2

Fig. 1

$$p_1 \frac{1 + log.e\ r}{r_1} - p_3 =$$

$$120 \times \frac{1 + 1.3863}{4} - 30 = 41.59$$

If the total number of expansions is 6.568 and 4 of them occur in the high-pressure cylinder, and there is no receiver drop, $6.58 \div 4 = 1.642$ of them must occur in the low-pressure cylinder, fixing the value of r_2 at that quantity. Then the mean effective pressure in the low-pressure cylinder is

$$p_3 \frac{1 + log.e\ r_2}{r_2} - p_5$$

$$30 \times \frac{1 + 0.4959}{1.642} - 2$$

$$30 \times 0.911 - 2 = 25.33 \textit{ pounds}$$

This pressure acting in a cylinder having 1.64 times the area of the high pressure will develop the same power as

$$25.33 \times 1.642 = 41.59 \textit{ pounds}$$

in the high pressure; and this is the mean effective pressure in that cylinder as determined above.

But in the inspector's example this ratio is given, and it is the receiver pressure which must be varied.

The area representing the net work in the high-pressure cylinder is $A\,B\,C\,H\,J$ $(1 + log.e\ r)$ minus the back-pressure area $L\,R\,H\,J = \left(\frac{p_3}{p_1} r\right)$.

High-pressure area $= 1 + log_e.\ r - \frac{p_3}{p_1} r_1$.

The area representing the work done in the low-pressure cylinder is $L\,M\,D\,F\,J =$ $1 + log.e\ r_2$ minus $I\,E\,F\,J = \frac{p_5}{p_1} R$. Low-pressure area $= 1 + log.e\ r_2 - \frac{p_5}{p_1} R$

and these are to be equal so that

$$1 + log.e\ r_1 - \frac{p_3}{p_1} r_1 = 1 + log.e\ r_2 - \frac{p_5}{p_1} R$$

$$log.e\ r_1 + \frac{p_5}{p_1} R = log.e\ r_2 + \frac{p_3}{p_1} r_1$$

but

$$p_3 = \frac{p_1}{R} r_2 \text{ and } \frac{p_3}{p_1} r_1 = \frac{r_1}{R} r_2$$

Substituting this expression for the last term the formula becomes

$$log.e\ r_1 + \frac{p_5}{p_1} R = log.e\ r_2 + \frac{r_1}{R} r_2 \quad (2)$$

Try the case of an engine with 120 pounds absolute initial pressure (p_1); four expansions in the high-pressure cylinder (r_1); cylinder ratio (λ) 3; back

TO FIND CYLINDER RATIO WHICH WILL PRODUCE EQUAL DISTRIBUTION OF WORK

$$\log_e r_1 + \frac{p_s}{p_1} R = \log_e r_2 + \frac{r_1}{R} r_2$$

Ratio of Expansion in Low Pressure.	Cylinder Ratio or $\frac{R}{r_1}$																		
	1.5	1.75	2.00	2.25	2.50	2.75	3.00	3.25	3.50	3.75	4.00	4.25	4.50	4.75	5.00	5.25	5.50	5.75	6.00
1.5	1.4055	1.2626	1.1555	1.0722	1.0055	0.9510	0.9055	0.8670	0.8341	0.8055	0.7805	0.7584	0.7388	0.7213	0.7055	0.6912	0.6782	0.6664	0.6555
1.6	1.5367	1.3843	1.2700	1.1811	1.1100	1.0518	1.0033	0.9623	0.9271	0.8967	0.8700	0.8465	0.8256	0.8068	0.7900	0.7748	0.7609	0.7483	0.7367
1.7	1.6639	1.5020	1.3806	1.2862	1.2106	1.1488	1.0973	1.0537	1.0163	0.9839	0.9556	0.9306	0.9084	0.8885	0.8706	0.8544	0.8397	0.8263	0.8139
1.8	1.7878	1.6164	1.4878	1.3878	1.3078	1.2423	1.1878	1.1416	1.1021	1.0678	1.0378	1.0113	0.9878	0.9667	0.9478	0.9307	0.9151	0.9008	0.8878
1.9	1.9086	1.7276	1.5919	1.4863	1.4019	1.3328	1.2752	1.2265	1.1848	1.1486	1.1169	1.0890	1.0641	1.0419	1.0219	1.0038	0.9874	0.9723	0.9586
2.0	2.0264	1.8360	1.6931	1.5819	1.4931	1.4204	1.3597	1.3085	1.2645	1.2264	1.1931	1.1637	1.1375	1.1142	1.0931	1.0741	1.0567	1.0409	1.0264
2.1	2.1419	1.9419	1.7919	1.6752	1.5819	1.5055	1.4419	1.3881	1.3419	1.3019	1.2669	1.2360	1.2086	1.1840	1.1619	1.1419	1.1237	1.1071	1.0919
2.2	2.2552	2.0456	1.8885	1.7663	1.6685	1.5885	1.5218	1.4654	1.4171	1.3752	1.3385	1.3061	1.2774	1.2517	1.2285	1.2075	1.1885	1.1711	1.1552
2.3	2.3662	2.1472	1.9829	1.8551	1.7529	1.6693	1.5996	1.5406	1.4900	1.4462	1.4079	1.3741	1.3440	1.3171	1.2929	1.2710	1.2511	1.2329	1.2162
2.4	2.4755	2.2469	2.0755	1.9422	1.8355	1.7482	1.6755	1.6140	1.5612	1.5155	1.4755	1.4402	1.4088	1.3808	1.3555	1.3326	1.3119	1.2929	1.2755
2.5	2.5830	2.3449	2.1663	2.0274	1.9163	1.8254	1.7496	1.6855	1.6306	1.5830	1.5413	1.5045	1.4719	1.4426	1.4163	1.3925	1.3708	1.3511	1.3330
2.6	2.6888	2.4412	2.2555	2.1111	1.9955	1.9010	1.8222	1.7555	1.6984	1.6488	1.6055	1.5673	1.5333	1.5029	1.4755	1.4507	1.4282	1.4077	1.3888
2.7	2.7933	2.5362	2.3433	2.1933	2.0733	1.9751	1.8933	1.8241	1.7647	1.7133	1.6683	1.6286	1.5933	1.5617	1.5333	1.5076	1.4842	1.4629	1.4433
2.8	2.8963	2.6296	2.4296	2.2740	2.1496	2.0478	1.9629	1.8911	1.8296	1.7763	1.7296	1.6884	1.6518	1.6191	1.5896	1.5629	1.5387	1.5166	1.4963
2.9	2.9980	2.7218	2.5147	2.3536	2.2247	2.1192	2.0314	1.9570	1.8933	1.8380	1.7897	1.7471	1.7091	1.6752	1.6447	1.6171	1.5920	1.5690	1.5480
3.0	3.0986	2.8129	2.5986	2.4319	2.2986	2.1895	2.0986	2.0217	1.9557	1.8986	1.8486	1.8045	1.7653	1.7302	1.6986	1.6700	1.6441	1.6203	1.5986
3.1	3.1981	2.9028	2.6814	2.5092	2.3714	2.2587	2.1647	2.0852	2.0171	1.9581	1.9064	1.8608	1.8203	1.7840	1.7514	1.7219	1.6950	1.6705	1.6481
3.2	3.2965	2.9918	2.7632	2.5854	2.4432	2.3268	2.2299	2.1478	2.0775	2.0165	1.9632	1.9161	1.8743	1.8369	1.8032	1.7727	1.7450	1.7197	1.6965
3.3	3.3939	3.0796	2.8439	2.6606	2.5139	2.3939	2.2939	2.2093	2.1368	2.0739	2.0189	1.9704	1.9272	1.8886	1.8539	1.8225	1.7939	1.7678	1.7439
3.4	3.4905	3.1667	2.9238	2.7349	2.5838	2.4602	2.3571	2.2700	2.1952	2.1305	2.0738	2.0238	1.9794	1.9396	1.9038	1.8714	1.8420	1.8151	1.7905
3.5	3.5861	3.2528	3.0028	2.8084	2.6528	2.5255	2.4195	2.3297	2.2528	2.1861	2.1278	2.0763	2.0306	1.9896	1.9528	1.9195	1.8892	1.8615	1.8361
3.6	3.6809	3.3380	3.0809	2.8809	2.7209	2.5900	2.4809	2.3886	2.3095	2.2409	2.1809	2.1280	2.0809	2.0388	2.0009	1.9666	1.9354	1.9070	1.8809
3.7	3.7750	3.4226	3.1583	2.9527	2.7883	2.6538	2.5416	2.4468	2.3654	2.2950	2.2333	2.1789	2.1305	2.0872	2.0483	2.0131	1.9810	1.9518	1.9250
3.8	3.8683	3.5064	3.2350	3.0239	2.8550	2.7168	2.6017	2.5042	2.4207	2.3483	2.2850	2.2291	2.1794	2.1350	2.0950	2.0588	2.0259	1.9959	1.9683
3.9	3.9610	3.5896	3.3110	3.0943	2.7210	2.7792	2.6610	2.5610	2.4753	2.4010	2.3360	2.2786	2.2277	2.1421	2.1410	2.1039	2.0701	2.0393	2.0110
4.0	4.0530	3.6720	3.3863	3.1641	2.9863	2.8408	2.7196	2.6171	2.5292	2.4530	2.3863	2.3275	2.2752	2.2284	2.1863	2.1482	2.1136	2.0820	2.0530
4.1	4.1443	3.7539	3.4610	3.2332	3.0510	2.9019	2.7777	2.6725	2.5824	2.5043	2.4360	2.3757	2.3221	2.2742	2.2310	2.1920	2.1565	2.1240	2.0943
4.2	4.2351	3.8351	3.5351	3.3018	3.1151	2.9624	2.8351	2.7274	2.6351	2.5551	2.4851	2.4233	2.3684	2.3193	2.2751	2.2351	2.1987	2.1655	2.1351
4.3	4.3253	3.9157	3.6086	3.3697	3.1786	3.0222	2.8919	2.7817	2.6872	2.6053	2.5336	2.4704	2.4142	2.3639	2.3186	2.2776	2.2404	2.2064	2.1753
4.4	4.4149	3.9959	3.6816	3.4372	3.2416	3.0816	2.9483	2.8354	2.7387	2.6549	2.5816	2.5169	2.4594	2.4079	2.3616	2.3197	2.2816	2.2468	2.2149
4.5	4.5041	4.0755	3.7541	3.5041	3.3041	3.1405	3.0041	2.8887	2.7898	2.7041	2.6291	2.5629	2.5041	2.4515	2.4041	2.3612	2.3223	2.2867	2.2541
4.6	4.5928	4.1547	3.8261	3.5705	3.3661	3.1988	3.0594	2.9415	2.8404	2.7528	2.6761	2.6085	2.5483	2.4945	2.4461	2.4023	2.3625	2.3261	2.2928
4.7	4.6809	4.2333	3.8976	3.6365	3.4276	3.2567	3.1143	2.9938	2.8905	2.8009	2.7226	2.6535	2.5920	2.5371	2.4876	2.4428	2.4021	2.3650	2.3309
4.8	4.7686	4.3115	3.9686	3.7019	3.4886	3.3141	3.1686	3.0455	2.9400	2.8486	2.7686	2.6980	2.6353	2.5791	2.5286	2.4829	2.4413	2.4034	2.3686
4.9	4.8559	4.3892	4.0392	3.7670	3.5492	3.3710	3.2225	3.0969	2.9892	2.8959	2.8142	2.7421	2.6781	2.6208	2.5692	2.5225	2.4801	2.4414	2.4059
5.0	4.9427	4.4665	4.1094	3.8316	3.6094	3.4276	3.2761	3.1479	3.0380	2.9427	2.8594	2.7859	2.7205	2.6620	2.6094	2.5618	2.5185	2.4790	2.4427
5.1	5.0292	4.5435	4.1792	3.8959	3.6692	3.4837	3.3292	3.1984	3.0863	2.9892	2.9042	2.8292	2.7625	2.7029	2.6492	2.6006	2.5565	2.5162	2.4792
5.2	5.1154	4.6201	4.2487	3.9598	3.7287	3.5396	3.3820	3.2487	3.1344	3.0354	2.9487	2.8722	2.8043	2.7434	2.6887	2.6392	2.5942	2.5530	2.5154
5.3	5.2010	4.6963	4.3177	4.0233	3.7877	3.5950	3.4344	3.2985	3.1820	3.0810	2.9927	2.9148	2.8455	2.7835	2.7277	2.6772	2.6313	2.5894	2.5510
5.4	5.2864	4.7721	4.3864	4.0864	3.8464	3.6500	3.4864	3.3479	3.2293	3.1264	3.0364	2.9570	2.8864	2.8232	2.7664	2.7150	2.6682	2.6255	2.5864
5.5	5.3714	4.8476	4.4547	4.1491	3.9047	3.7047	3.5380	3.3970	3.2761	3.1714	3.0797	2.9988	2.9269	2.8626	2.8047	2.7523	2.7047	2.6612	2.6214
5.6	5.4561	4.9228	4.5228	4.2117	3.9628	3.7592	3.5896	3.4459	3.3228	3.2161	3.1228	3.0404	2.9672	2.9017	2.8428	2.7895	2.7410	2.6967	2.6561
5.7	5.5405	5.0976	4.5905	4.2738	4.0205	3.8132	3.6405	3.4943	3.3691	3.2605	3.1655	3.0817	3.0072	2.9405	2.8805	2.8262	2.7769	2.7318	2.6905
5.8	5.6246	5.0722	4.6579	4.3357	4.0779	3.8670	3.6912	3.5425	3.4150	3.3046	3.2079	3.1226	3.0468	2.9790	2.9179	2.8627	2.8124	2.7666	2.7246
5.9	5.7083	5.1464	4.7250	4.3972	4.1350	3.9205	3.7417	3.5904	3.4607	3.3483	3.2500	3.1632	3.1861	3.0171	2.9550	2.8988	2.8477	2.8011	2.7583
6.0	5.7918	5.2204	4.7918	4.4585	4.1918	3.9736	3.7918	3.6380	3.5061	3.3918	3.2918	3.2036	3.1251	3.0550	2.9918	2.9347	2.8827	2.8353	2.7918

TO FIND RECEIVER PRESSURE FOR EQUAL WORK WITH GIVEN CYLINDER RATIO

$$2\log_e r_1 - 1 = \log_e R - \frac{p_s}{p_1} R$$

$\frac{p_s}{p_1}$	Total Ratio of Expansion																		
	6	6.5	7	7.5	8	8.5	9	9.5	10	11	12	13	14	15	16	17	18	19	20
0.005	1.7618	1.8393	1.9109	1.9774	2.0394	2.0976	2.1522	2.2038	2.2526	2.3429	2.4249	2.4999	2.5691	2.6331	2.6926	2.7482	2.8004	2.8494	2.8957
0.010	1.7318	1.8068	1.8759	1.9399	1.9994	2.0551	2.1072	2.1563	2.2026	2.2879	2.3649	2.4349	2.4991	2.5581	2.6126	2.6632	2.7104	2.7544	2.7957
0.015	1.7018	1.7743	1.8409	1.9024	1.9594	2.0126	2.0622	2.1088	2.1526	2.2329	2.3049	2.3699	2.4291	2.4831	2.5326	2.5782	2.6204	2.6594	2.6957
0.020	1.6718	1.7418	1.8059	1.8649	1.9194	1.9701	2.0172	2.0613	2.1026	2.1779	2.2449	2.3049	2.3591	2.4081	2.4526	2.4932	2.5304	2.5644	2.5957
0.025	1.6418	1.7093	1.7709	1.8274	1.8794	1.9276	1.9722	2.0138	2.0526	2.1229	2.1849	2.2399	2.2891	2.3331	2.3726	2.4082	2.4404	2.4694	2.4957
0.030	1.6118	1.6768	1.7359	1.7899	1.8394	1.8851	1.9272	1.9663	2.0026	2.0679	2.1249	2.1749	2.2191	2.2581	2.2926	2.3232	2.3504	2.3744	2.3957
0.035	1.5818	1.6443	1.7009	1.7524	1.7994	1.8426	1.8822	1.9188	1.9526	2.0129	2.0649	2.1099	2.1491	2.1831	2.2126	2.2382	2.2604	2.2794	2.2957
0.040	1.5518	1.6118	1.6659	1.7149	1.7594	1.8001	1.8372	1.8713	1.9026	1.9579	2.0049	2.0449	2.0791	2.1081	2.1326	2.1532	2.1704	2.1844	2.1957
0.045	1.5218	1.5793	1.6309	1.6774	1.7194	1.7576	1.7922	1.8238	1.8526	1.9029	1.9449	1.9799	2.0091	2.0331	2.0526	2.0682	2.0804	2.0894	2.0957
0.050	1.4918	1.5468	1.5959	1.6399	1.6794	1.7151	1.7472	1.7763	1.8026	1.8479	1.8849	1.9149	1.9391	1.9581	1.9726	1.9832	1.9904	1.9944	1.9957
0.055	1.4618	1.5143	1.5609	1.6024	1.6394	1.6726	1.7022	1.7288	1.7526	1.7929	1.8249	1.8499	1.8691	1.8831	1.8926	1.8982	1.9004	1.8994	1.8957
0.060	1.4318	1.4818	1.5259	1.5649	1.5994	1.6301	1.6572	1.6813	1.7026	1.7379	1.7649	1.7849	1.7991	1.8081	1.8126	1.8132	1.8104	1.8044	1.7957
0.065	1.4018	1.4493	1.4909	1.5274	1.5594	1.5876	1.6122	1.6338	1.6526	1.6829	1.7049	1.7199	1.7291	1.7331	1.7326	1.7282	1.7204	1.7094	1.6957
0.070	1.3718	1.4168	1.4559	1.4899	1.5194	1.5451	1.5672	1.5863	1.6026	1.6279	1.6449	1.6549	1.6591	1.6581	1.6526	1.6432	1.6304	1.6144	1.5957
0.075	1.3418	1.3843	1.4209	1.4524	1.4794	1.5026	1.5222	1.5388	1.5526	1.5729	1.5849	1.5899	1.5891	1.5831	1.5726	1.5582	1.5404	1.5194	1.4957
0.080	1.3118	1.3518	1.3859	1.4149	1.4394	1.4601	1.4772	1.4913	1.5026	1.5179	1.5249	1.5249	1.5191	1.5081	1.4926	1.4732	1.4504	1.4244	1.3957
0.085	1.2818	1.3193	1.3509	1.3774	1.3994	1.4176	1.4322	1.4438	1.4526	1.4629	1.4649	1.4599	1.4491	1.4331	1.4126	1.3882	1.3604	1.3294	1.2957
0.090	1.2518	1.2868	1.3159	1.3399	1.3594	1.3751	1.3872	1.3963	1.4026	1.4079	1.4049	1.3949	1.3791	1.3581	1.3326	1.3032	1.2704	1.2344	1.1957
0.095	1.2218	1.2543	1.2809	1.3024	1.3194	1.3326	1.3422	1.3488	1.3526	1.3529	1.3449	1.3299	1.3091	1.2831	1.2526	1.2182	1.1804	1.1394	1.0957
0.100	1.1918	1.2218	1.2459	1.2649	1.2794	1.2901	1.2972	1.3013	1.3026	1.2979	1.2849	1.2649	1.2391	1.2081	1.1726	1.1332	1.0904	1.0444	0.9957
0.105	1.1618	1.1893	1.2109	1.2274	1.2394	1.2476	1.2522	1.2538	1.2526	1.2429	1.2249	1.1999	1.1691	1.1331	1.0926	1.0482	1.0004	0.9494	0.8957
0.110	1.1318	1.1568	1.1759	1.1899	1.1994	1.2051	1.2072	1.2063	1.2026	1.1879	1.1649	1.1349	1.0991	1.0581	1.0126	0.9632	0.9104	0.8544	0.7957
0.115	1.1018	1.1243	1.1409	1.1524	1.1594	1.1626	1.1622	1.1588	1.1526	1.1329	1.1049	1.0699	1.0291	0.9831	0.9326	0.8782	0.8204	0.7594	0.6957
0.120	1.0718	1.0918	1.1059	1.1149	1.1194	1.1201	1.1172	1.1113	1.1026	1.0779	1.0449	1.0049	0.9591	0.9081	0.8526	0.7932	0.7304	0.6644	0.5957
0.125	1.0418	1.0593	1.0709	1.0774	1.0794	1.0776	1.0722	1.0638	1.0526	1.0229	0.9849	0.9399	0.8891	0.8331	0.7726	0.7082	0.6404	0.5694	0.4957
0.130	1.0118	1.0268	1.0359	1.0399	1.0394	1.0351	1.0272	1.0163	1.0026	0.9679	0.9249	0.8749	0.8191	0.7581	0.6926	0.6232	0.5504	0.4744	0.3957
0.135	0.9818	0.9943	1.0009	1.0024	0.9994	0.9926	0.9822	0.9688	0.9526	0.9129	0.8649	0.8099	0.7491	0.6831	0.6126	0.5382	0.4604	0.3794	0.2957
0.140	0.9518	0.9618	0.9659	0.9649	0.9594	0.9501	0.9372	0.9213	0.9026	0.8579	0.8049	0.7449	0.6791	0.6081	0.5326	0.4532	0.3704	0.2844	0.1957
0.145	0.9218	0.9293	0.9309	0.9274	0.9194	0.9076	0.8922	0.8738	0.8526	0.8029	0.7449	0.6799	0.6091	0.5331	0.4526	0.3682	0.2804	0.1894	0.0957
0.150	0.8918	0.8968	0.8959	0.8899	0.8794	0.8651	0.8472	0.8263	0.8026	0.7479	0.6849	0.6149	0.5391	0.4581	0.3726	0.2832	0.1904	0.0944	$\bar{1}$.9957
0.155	0.8618	0.8643	0.8609	0.8524	0.8394	0.8226	0.8022	0.7788	0.7526	0.6929	0.6249	0.5499	0.4691	0.3831	0.2926	0.1982	0.1004	$\bar{1}$.9994	$\bar{1}$.8957
0.160	0.8318	0.8318	0.8259	0.8149	0.7994	0.7801	0.7572	0.7313	0.7026	0.6379	0.5649	0.4849	0.3991	0.3081	0.2126	0.1132	0.0104	$\bar{1}$.9044	$\bar{1}$.7957
0.165	0.8018	0.7993	0.7909	0.7774	0.7594	0.7376	0.7122	0.6838	0.6526	0.5829	0.5049	0.4199	0.3291	0.2331	0.1326	0.0282	$\bar{1}$.9204	$\bar{1}$.8094	$\bar{1}$.6957
0.170	0.7718	0.7668	0.7559	0.7399	0.7194	0.6951	0.6672	0.6363	0.6026	0.5279	0.4449	0.3549	0.2591	0.1581	0.0526	$\bar{1}$.9432	$\bar{1}$.8304	$\bar{1}$.7144	$\bar{1}$.5957
0.175	0.7418	0.7343	0.7209	0.7024	0.6794	0.6526	0.6222	0.5888	0.5526	0.4729	0.3849	0.2899	0.1891	0.0831	$\bar{1}$.9726	$\bar{1}$.8582	$\bar{1}$.7404	$\bar{1}$.6194	$\bar{1}$.4957
0.180	0.7118	0.7018	0.6859	0.6649	0.6394	0.6101	0.5772	0.5413	0.5026	0.4179	0.3249	0.2249	0.1191	0.0081	$\bar{1}$.8926	$\bar{1}$.7732	$\bar{1}$.6504	$\bar{1}$.5244	$\bar{1}$.3957
0.185	0.6818	0.6693	0.6509	0.6274	0.5994	0.5676	0.5322	0.4938	0.4526	0.3629	0.2649	0.1599	0.0491	$\bar{1}$.9331	$\bar{1}$.8126	$\bar{1}$.6882	$\bar{1}$.5604	$\bar{1}$.4294	$\bar{1}$.2957
0.190	0.6518	0.6368	0.6159	0.5899	0.5594	0.5251	0.4872	0.4463	0.4026	0.3079	0.2049	0.0949	$\bar{1}$.9791	$\bar{1}$.8581	$\bar{1}$.7326	$\bar{1}$.6032	$\bar{1}$.4704	$\bar{1}$.3344	$\bar{1}$.1957
0.195	0.6218	0.6043	0.5809	0.5524	0.5194	0.4826	0.4422	0.3988	0.3526	0.2529	0.1449	0.0299	$\bar{1}$.9091	$\bar{1}$.7831	$\bar{1}$.6526	$\bar{1}$.5182	$\bar{1}$.3804	$\bar{1}$.2394	$\bar{1}$.0957
0.200	0.5918	0.5718	0.5459	0.5149	0.4794	0.4401	0.3972	0.3513	0.3026	0.1979	0.0849	$\bar{1}$.9649	$\bar{1}$.8391	$\bar{1}$.7081	$\bar{1}$.5726	$\bar{1}$.4332	$\bar{1}$.2904	$\bar{1}$.1444	$\bar{2}$.9957

pressure (p_s) 2 pounds absolute, what is the receiver pressure?

$$\begin{array}{llll} & & & log.e \\ p_1 \text{ given} = 120 & & r_1 = 4 & = 1.3863 \\ p_2 = p_1 \div r_1 = 30 & & r_2 = 2.283 & = 0.8255 \\ p_3 & (?) & R = r_1 \lambda = 12 & = 2.4849 \\ p_4 = p_1 \div R = 10 & & \lambda \text{ given} = 3 & \\ p_5 \text{ given} = 2 & & & \end{array}$$

$$1.3863 + \frac{2}{120} \times 12 = log.e\, r_2 + \frac{4}{12} r_2$$

$$1.5863 = log.e\, r_2 + \tfrac{1}{3} r_2$$

We must now look in the table for a hyperbolic logarithm which when it has one-third of the number to which it corresponds added to it will equal 1.5863.

Try that corresponding to 2.30.

$$3)\underline{2.30} = 0.8329$$
$$0.7667 \quad 0.7667$$
$$1.5996 \text{ this is too large}$$

$$3)\underline{2.25} = 0.8109$$
$$0.75 \quad 0.75$$
$$.5609 \text{ this is too small}$$

The value of r_2 is evidently between 2.25 and 2.30. By successive trials I find that 2.283 will make

$$log.e\ 2.283 + \frac{2.283}{3} = 1.5865$$

which is near enough. The *log.e* of this number is 0.8255.

The upper part of the accompanying table will help in locating this value. In the vertical column corresponding to the given cylinder ratio (in this case 3) look for the number most nearly corresponding to the calculated value (in this case 1.5863). The nearest value there given is 1.5996 corresponding to a ratio of expansion in the low-pressure cylinder of 2.3 in the first column.

Since 2.283 is the number of expansions which the steam gets in the low-pressure cylinder the initial pressure in that cylinder will be 2.283 times the terminal, and the terminal is 10 pounds. The initial pressure in the low-pressure cylinder and the receiver pressure are, therefore,

$$10 \times 2.283 = 22.83 \textit{ pounds}$$

PROOF

$$M.e.p.\ in\ high = p_1 \frac{1 + log.e\, r}{r_1} - p_3$$

$$120 \times \frac{2.3863}{4} - 22.83 = 48.76 \textit{ pounds}$$

$$M.e.p.\ in\ low = p_2 \frac{1 + log.e\, r_2}{r_2} - p_5$$

$$22.83 \times \frac{1.8255}{2.283} - 2 = 16.255 \textit{ pounds}$$

As the low-pressure cylinder has 3 times the area it will do 3 times the work with the same mean effective pressure:

$$16.225 \times 3 = 48.76$$

showing that its work under the given conditions will be the same as that of the high-pressure cylinder.

Recent Developments in Testing Boiler Tubes

BY F. N. SPELLER*

In a paper upon "Locomotive Tubes and their Treatment," read before the Pittsburg Railway Club and reported in our issue of May 23, Mr. Speller described the method followed by the National Tube Company for testing each tube before it was allowed to go out.

In the former paper Mr. Speller also called attention to the fact that a specification of not to exceed 0.05 per cent. phosphorus and 0.035 per cent. sulphur is apt to make it more difficult for the steelmaker to produce a perfectly welded tube without a compensating advantage to the buyer of the material. In the present paper, which was presented at

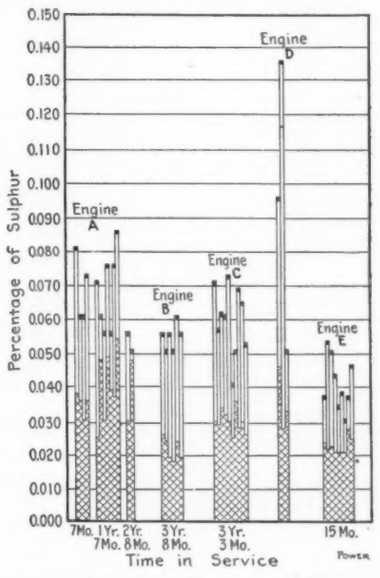


DIAGRAM SHOWING AMOUNT OF SULPHUR ABSORBED BY TUBE ENDS FROM FLUE GASES IN LOCOMOTIVE FIREBOX. LOWER SHADED PORTION SHOWS ORIGINAL SULPHUR. OPEN PORTION, INCREASE

the recent meeting of the American Society for Testing Materials, he enlarges upon this fact as follows:

Locomotive tubes, whether seamless or lap welded, must sooner or later be safe ended; hence the welding quality of the metal should be one of the first considerations in manufacture. Some specifications now written so restrict the chemical composition in some particulars as to hamper the manufacturer in making a good welding steel. There is no difficulty in making steel with a maximum of 0.03 per cent. phosphorus if necessary, but there is reason to believe that 0.05 phosphorus is a more reasonable maximum limit which does no harm, and, other conditions being equal, will give a tube better adapted to service and much more easily welded.

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Another restriction which experience teaches as operating against the best quality of locomotive tubes is unreasonable sulphur requirements. The highest sulphur allowed in samples taken from individual tubes is, in some cases, 0.035 per cent., which means that the ladle test must not exceed 0.030 per cent. With producer gas this signifies that the heat must often be held and a heavier burden of lime carried, which tends to render the steel "dry" in welding and more liable to be crystallized or burned.

Analyses of the surface of beads taken from tubes after being in the boiler some time show that sulphur is absorbed from the hot flue gases, so that if there is any advantage in using steel of 0.030 per cent. sulphur, it would appear to be only temporary. The results of this investigation are given in the accompanying diagram. The engines from which these tubes were taken had been operating on different roads under widely different conditions, but in each instance the tubes had all given equally good service and were being removed for safe ending. It also appears from a comparison of the sulphur taken up by individual tubes under the same conditions that there is no consistent relation between the original sulphur and the amount absorbed, so that it does not follow, because the tube was originally low sulphur, that it would therefore show comparatively low sulphur after being subject to the action of the hot flue gases; the results rather suggest that the low-sulphur tubes are more susceptible to sulphurizing by the hot flue gases.

A study of records in lap welding may throw some light on the relative influence of variations in sulphur contents. For example, two heats which had been rephosphorized gave the following welding records, each piece being tested in the flanging machine after the first run through the welding furnace and rejected if there was any indication of opening at the seam:

Heat No.	No. of Pieces	Chemical Analyses S	P	Mn	C	Per Cent. Not Welded
3432	1272	0.045	0.036	0.43	0.105	14.7
30522	1401	0.027	0.037	0.47	0.113	20.2

The average of nine heats of steel which ran 0.03 per cent. sulphur or less showed 20 per cent. more rejections on account of bad welds than eight heats where the sulphur ran over 0.04 per cent., these heats being nearly the same in other respects.

We believe it would be to the advantage of all concerned if a standard specification was agreed upon for boiler tubes, in which there would be no objection to a test on the ends of each tube along the lines described above, provided the chemical requirements were not unnecessarily restrictive.

Combined Coal and Ash Conveyer

Description of a pivoted bucket conveyer which has recently been installed at the power house of the Erie County Electric Company.

One of the interesting features of the power house which has recently been completed for the Erie County Electric Company, of Erie, Penn., is the coal- and ash-handling system.

Coal is brought to the power house in gondola cars and dumped into a track hopper from which it is discharged onto an overlapping pivoted bucket conveyer. Fig. 1 shows the track hopper delivering coal to the conveyer. This hopper is fitted with an automatic feeding device which regulates the flow of coal to the buckets, which are carried horizontally a distance of 31 feet and then vertically in an inclosed shaft to the top of the bins.

The coal is distributed over the storage bins by means of a traveling tripper, operated by a winch and handwheel placed at one end of the runway. The storage bins and the upper run of the

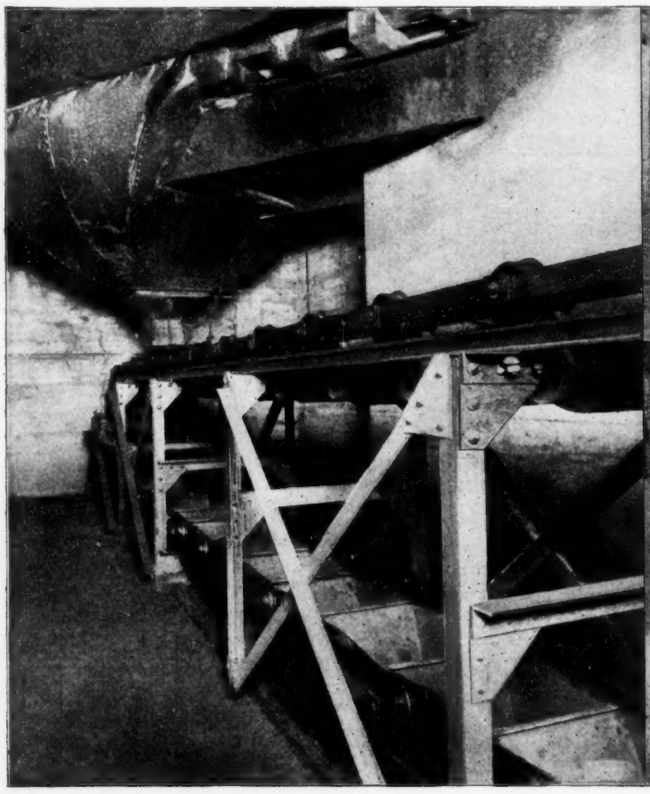


FIG. 1. TRACK HOPPER DELIVERING COAL TO CONVEYER

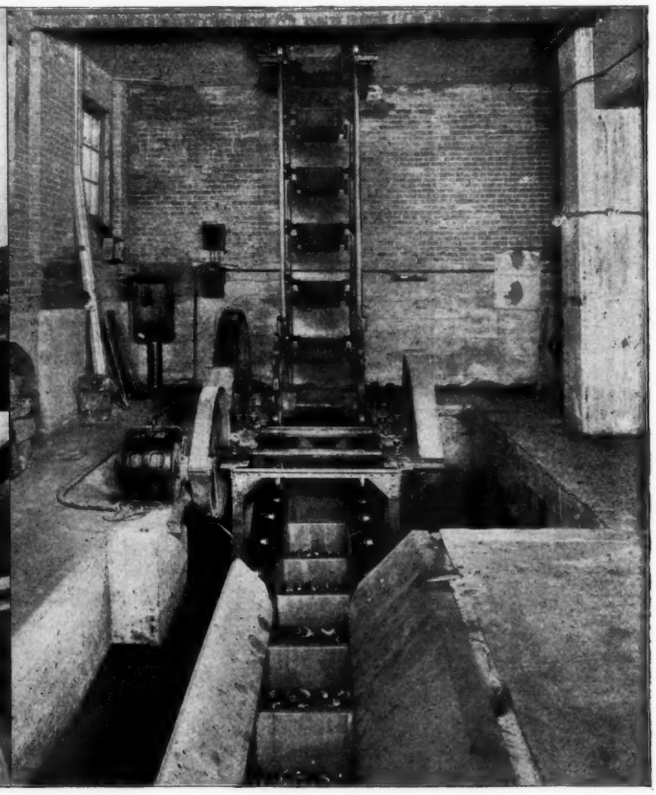


FIG. 2. DRIVING MECHANISM OF CONVEYER

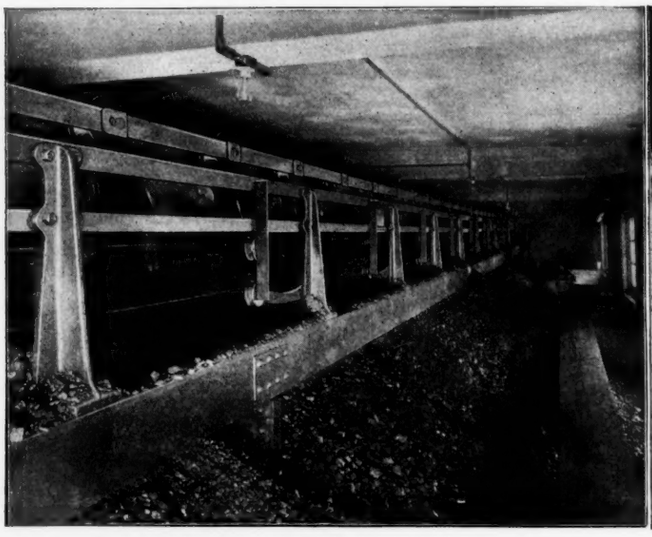


FIG. 3. STORAGE BINS AND UPPER RUN OF CONVEYER

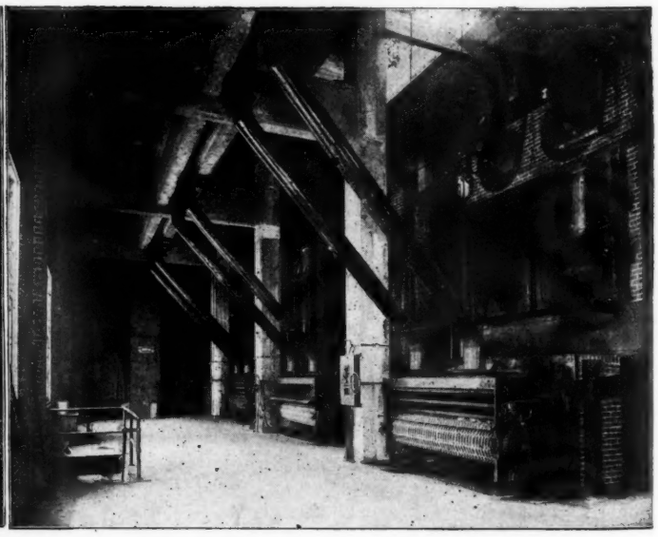


FIG. 4. HOPPER TO STOKER BY INCLINED CHUTES

conveyer are shown in Fig. 3. The coal is fed to the chain-grate stokers by means of inclined chutes, shown in Fig. 4.

The ashes are also handled by this conveyer line, as may be seen from the general layout in Fig. 5. They are drive and continuing up the curve. The ashes are carried around the system in the same way as the coal and are dumped into the ash chute by means of the traveling tripper. This ash chute discharges through the wall of the building to cars on a siding.

placed in the basement of the boiler house and consists of a head shaft, two countershafts and a 10-horsepower motor, all gear connected and supported on a steel frame. An automatic gear lock prevents the conveyer from running backward in the event of current

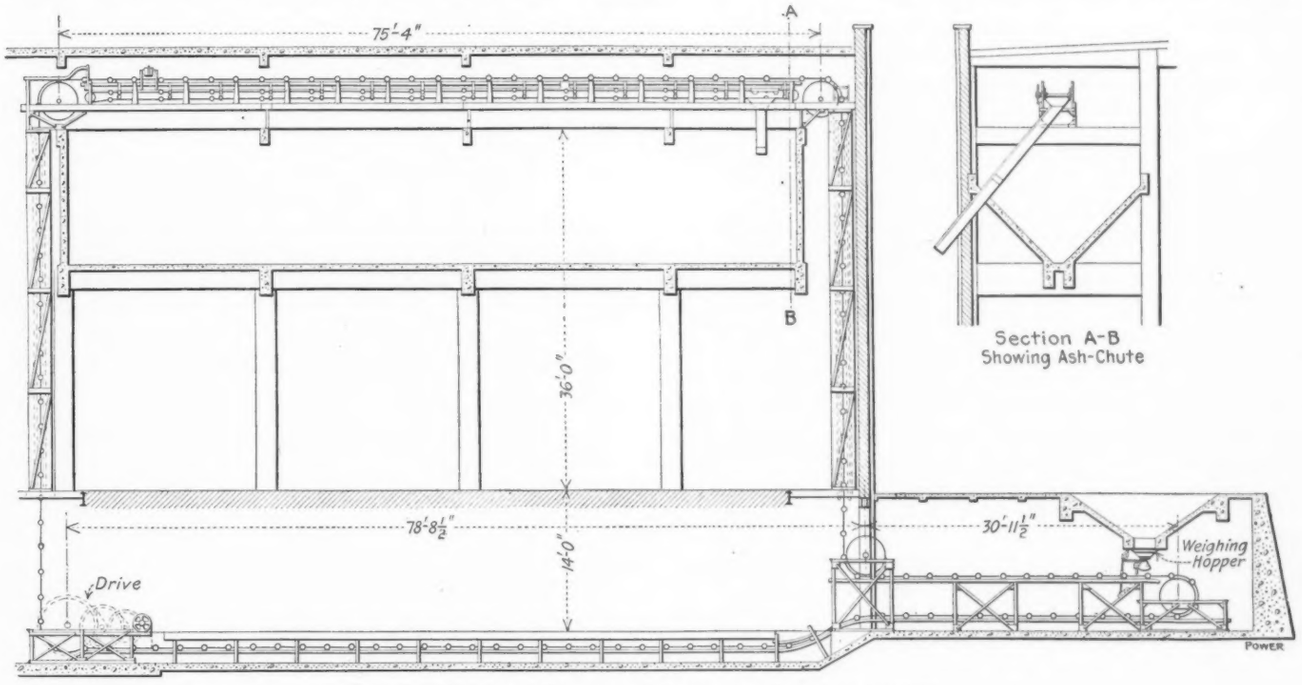


FIG. 5. VERTICAL ELEVATION SHOWING GENERAL LAYOUT

dumped from a hand car in the basement onto the lower run of the conveyer. Loading plates flush with the floor extend along this part of the conveyer for a distance of 62 feet, starting from the

The conveyer is 117 feet between vertical centers; it operates at a speed of 48 feet per minute and is capable of handling 50 tons of coal per hour. The driving mechanism, shown in Fig. 2, is

being thrown on while the motor is loaded.

The system was designed and installed by the Jeffrey Manufacturing Company.

Recent Work of U. S. Bureau of Mines*

A large percentage of the coal used by the departments of the Government is now purchased on a specification basis. During the current fiscal year the Bureau of Mines will analyze and report on samples representing approximately 1,100,000 tons, the contract price of which is over $3,000,000. This inspection work will probably be considerably increased during the next year.

The fuel-inspection work is mainly contracting for fuel supply and collecting samples for analysis, upon the results of which depend the settlements to the contractors, and analyzing these samples.

In drawing up the contracts and specifications for fuel for public buildings, the Isthmian canal commission, or the revenue-cutter service, consideration must be given to the fuels available in the market where deliveries are to be made, the character of the equipment and any other requirements resulting from special local conditions. In some instances the bureau has conducted tests in plants where a change in fuel seemed advisable in order

The bureau's inspection work is mainly contracting for Government fuel supply and analyzing samples, but boiler feed-water treatment in its bearing on the economical use of fuel and the fundamental principles of combustion are also under investigation.

*Abstract of a paper by S. B. Flagg and C. D. Smith, connected with the fuel-testing station at Pittsburg, Penn., and presented at the Pittsburg meeting of the American Society of Mechanical Engineers.

to obtain data as to the economy with which each of several coals could be used, and savings as great as 10 per cent. have resulted from the adoption of recommendations based on the results of such tests.

On some of the smaller contracts the cost of collecting and analyzing samples may equal or even offset the gain from buying on a specification basis; but any such loss is more apparent than real, as each additional contract awarded on such a basis helps to bring about a more careful preparation of the coal for the market and its more economical use. In arranging contracts and in selection of fuels it is frequently necessary to conduct some special investigations and then the engineers engaged in the sampling assist in the work.

During the years 1909 and 1910, the laboratories analyzed 7178 samples at a cost per sample of $1.54, or 1.33 cents per ton, which is 0.48 per cent. of the cost. For the current year the number of samples analyzed will be approximately 8786 and the laboratory cost will be $1.44 per sample. Computed on a tonnage basis, the cost will be 1.12 cents per ton, or 0.39 per cent. As the coal purchased by the Government is used in plants scattered all over the central and eastern portions of the United States,

as well as on the Isthmus of Panama, it is well nigh impossible to get any accurate data as to the net saving resulting from the specification method of purchase. Buying fuel in this way results in a number of benefits, one of the most marked of which is that the quality of the material delivered is much less variable than when purchased at a flat price. This means fewer operating difficulties, more general satisfaction and better economy. Some of the plant engineers state that by means of the analyses they can more easily check up their coal consumption and compel the fireman to be more careful. The Government has been also benefited in many cases since the inauguration of the coal-inspection work as lower-priced fuels have been substituted; in one plant alone there is a saving of nearly $800 per month.

Most of the coal-inspection work is carried on in Washington, where a laboratory for the analysis of inspection samples is maintained. The experimental work to be described is for the most part carried on at the Pittsburg testing station of the Bureau of Mines.

Laboratory investigations have been made of the fusibility and clinkering properties of coal ash and chemical and mineralogical examinations are being made of the ash in coal as it occurs in the coal and in the clinker to study the effect of the distribution of the ash in the coal and the influence of the component substances upon the clinkering tendency. The results obtained indicate that the composition of the clinker is much more uniform than that of the ash.

Boiler feed-water treatment is also being studied and while this is not a fuel problem *per se*, its bearing on the economical use of fuel in steam-boiler practice is evident. The present plans include a study of the scaling properties of various waters under temperature and pressure conditions such as are met with in practice, as well as the effect of the different methods of treatment. Such a study should furnish an explanation for the corrosive or pitting action of certain classes of waters, concerning which there is a lack of reliable information.

Because of the rapidly increasing production of petroleum, the scarcity of fuel and authentic information on the oilfields or the oil itself, the Government has published certain bulletins concerning the geology of some of the fields and the statistics of production. To meet a need for more complete information the Bureau of Mines, in 1907, began a study of the commercial value of the petroleums of the United States. Inasmuch as the California fields promised so much in the way of large and continued production and furnished a fuel so peculiarly adapted to use not only in stationary and locomotive practice but also in the navy and merchant marine, they were made the first subject for study.

Among the other studies of coal may be mentioned the investigations as to its chemical composition; experiments to determine the nature and quantity of volatile matter evolved when various coals are heated to different temperatures and at various rates of heating; tests to ascertain the deterioration of coal under various conditions of storage, and an investigation of the factors affecting the rate of formation of carbon monoxide.

Of the chemical composition of coal but little is known today beyond the information imparted from the usual ultimate analysis which gives simply the elements involved and the proportions of each. The isolation of some of the constituents of coal is also being investigated and a number of different substances have been obtained. By the use of inert solvents it has become possible to extract as much as 35 per cent. of the original coal. The evolution of volatile matter from coal under various conditions of temperature and rates of heating is frequently of considerable importance in the economic utilization of fuel, and tests have been made to determine the quantity and composition of the gases evolved from various coals when heated to temperatures varying from 400 to 1000 degrees Centigrade. The data thus obtained have been published in Bureau of Mines Bulletin No. 1, entitled "The Volatile Matter of Coal."

Tests of coals from the New River and Pocahontas districts to determine their deterioration under various storage conditions are of special interest, and analyses indicate that coal stored in sea water or fresh water does not deteriorate to any appreciable extent, and that these types of coals stored in the open air even under severe weathering conditions do not lose more than 1 per cent. of their heat value in a year. Similar tests are in progress upon coals stored in widely separated localities and reports will be made later. A thorough study is being made of spontaneous combustion in fuel. Through a circular letter a general inquiry has been made among coal consumers for data of actual experience in the matter for correlation and study. A study is also being made of the fundamental reactions involved, the rate of oxidation at different temperatures, the behavior of sulphur, the heat produced, etc., and several serious cases in actual commercial practice have been investigated on the ground.

The formation of carbon monoxide from carbon dioxide and carbon at different temperatures and gas velocities has a direct bearing on the combustion processes of a gas producer, as does also the dissociation of steam when passed through a bed of incandescent carbon. It has been found that the rate of formation of carbon monoxide increases rapidly as the temperature rises, thus indicating that from this standpoint alone it would be desirable to operate producers at as high temperatures as possible. The results of these investigations have been published in Bulletin No. 7, Bureau of Mines, entitled "Essential Factors in the Formation of Producer Gas."

Supplementing the laboratory investigations on fuel, tests are being conducted with larger apparatus or on commercial equipment to determine their practical application.

Extensive investigations have been made on the briquetting qualities of various fuels, and experiments on anthracite and bituminous coal, lignite and peat. Much of the earlier work was done to determine whether the higher grades of coals could be so improved by briquetting as to justify the cost of the work, but it has generally proved unprofitable.

There are in some parts of the country immense deposits of lignite where other fuel is obtainable only by long hauls; these raw lignites contain a large percentage of water and upon exposure to the atmosphere they tend to slack or disintegrate, making them unsatisfactory for many purposes and especially when they are shipped over considerable distances. Could these fuel deposits of lignite be so briquetted as to hold their form during handling and storage and with a material decrease of moisture content, it would be of great advantage to many consumers of fuel. The more recent briquetting work aims to overcome these objections.

The present equipment of the briquetting plant consists of an English machine, which is suitable only for fuels requiring a binder, and a German lignite machine of heavy construction. The lignite machine is used in Germany with great success for briquetting brown coal; the press is of the open-mold type and is driven by a direct-connected steam engine; it has a capacity of from 2½ to 3 tons per hour and develops a pressure on the briquet of from 14,000 to 28,000 pounds per square inch. This press is only adapted for those varieties of peat and lignites which contain a sufficient quantity of natural binder. The material to be briquetted must be dried to contain not more than 15 per cent., or less than 5 per cent. of water, the exact percentages necessary varying with the different lignites. The tests have been made on samples of lignites coming from Texas, North Dakota and California; the object being to determine if American lignites could be briquetted without an artificial binder under the same conditions as prevail in Germany for briquetting brown coal. The briquets were made elliptical in one section and rectangular in the others, with dimensions approximately 6¼x2½x1 inch and with an average weight of approximately a pound each. As a result of these tests it was found that briquets could be made with-

out the use of binding material from the lignites of the three fields investigated. The briquets from the California fuel were strong and firm and withstood handling exceptionally well and resisted the effects of the weather for several months. The briquets made from the North Dakota fuel were also satisfactory so far as form and strength were concerned, but did not withstand the effects of weather so well as those made of California lignite. Material from the Texas field was briquetted only with considerable difficulty and the briquets obtained were weak in structure, poor in form and did not resist the effects of the weather at all. Tests of the latter, however, should hardly be considered complete, as some of the samples shipped to the bureau were entirely used up before satisfactory results had been reached. The indications are that Texas lignites and some samples of North Dakota lignites would require the use of binding material to produce commercial briquets. These tests also show that the reduction of the moisture in the briquetting process increased the heat value of the briquets obtained from 37 to 54 per cent. above that of the raw fuel, and increase is of great importance to the consumer as a greater efficiency is obtained from the combustion of fuels of high heat value than from those of lower heat value. The experiments have also conclusively demonstrated that the briquetted lignite withstands the effects of weathering several months longer than the raw fuel as the moisture content is reduced to a stable condition in the process of briquetting. It is expected that further tests will be made with this equipment on other lignites of the country.

During the past year briquetting experiments have been made on a sample of Philippine Island coal, which, while inferior to the best of American coals, is of interest because it offers a local supply of fuel to the Philippines, where the price of coal is high, and in the briquetted form it may provide a supply of steamer fuel to vessels touching at ports on these islands. Excellent briquets have been made from this fuel, but the cost is high on account of the large percentage of binder required.

Experiments on washing and coking in beehive coke ovens have demonstrated the possibility of coking coals which have been considered as noncoking, but no work along this line is being carried on as it is felt that further experiments with ovens of the beehive type are not of sufficient value to warrant their continuance.

During the past few years the introduction of gas producers for power purposes has created a new field in power development and has made possible the generation of power, even in small units, with a very small fuel consumption. The development of the power gas producer promises to be the means by which large quantities of low-grade fuels may be successfully and economically utilized.

At the time the fuel-testing work was inaugurated very few power-producer plants were operating on anthracite coal only, but to demonstrate the possibility of using practically all grades of fuel of any commercial value the producer-gas investigations were undertaken. Over 160 tests were made on a great variety of fuels and in general with very satisfactory results. Subsequent tests were made when special attention was given to the utilization in gas producers of low-grade fuels such as bone coal, washery refuse, peat, lignite, etc. Although many of these tests gave results which would hardly warrant at the present time the utilization of the poorer grades for commercial purposes, yet they did show that fuel of this type can be readily gasified and that the quality of the gas produced is nearly equal to that made from marketable coal.

The realization of the lack of exact knowledge of furnace requirements resulted in the decision to separate the boiler and furnace problems and take up the study of the latter.

For this purpose the bureau now has at the testing station a specially constructed furnace and combustion chamber. A Murphy mechanical stoker with grate surface 5x5 feet located about 35 feet from a hand-fired Heine boiler, has a firebrick-lined tunnel or combustion chamber proper of the boiler setting. This tunnel has a cross-sectional area about 3x3 feet with an arched roof. When experiments are to be conducted in this long chamber the space between the top of the bridgewall and the tile roof of the Heine boiler furnace is bricked up. The fire- and ashpit-door openings of the hand-fired furnace are also sealed and the gases from the combustion of the coal in the Murphy stoker pass through the tunnel and enter at the side and near the rear of the boiler setting. After entering the combustion chamber of the boiler the gases then pass over the heating surfaces in the usual manner.

The problems being studied in this equipment are those connected with the fundamental principles of combustion. Engineers who have any considerable amount of work with furnaces for any purpose realize that to secure efficient and smokeless combustion of a coal, the combustible gases must come in contact with the air supplied and mix with it, and burn before they come in contact with surfaces which will reduce their temperature below the ignition point. More combustion space is required when burning a coal high in volatile matter than when burning an anthracite or semi-bituminous coal, but as to just what space the different kinds of coals do require for various rates of combustion, there are few valuable data.

The work now planned for the long combustion chamber includes tests with each of several typical coals at varying rates of combustion. In these tests the effect of the following-named factors upon the space required for complete combustion are being studied:

Nature of the coal, rate of combustion, supply of air, rate of heating fuel, rate of mixing volatile combustible and air.

The completeness of combustion is determined by the gas analyses. Provision is made for taking samples at several points in a plane perpendicular to the longitudinal center line of the tunnel, at the center of the bridgewall, and in similar planes every 5 feet from the bridgewall to the end of the long chamber. At these same cross-sections temperatures can also be taken with optical or radiation pyrometers, or with thermocouples where the temperature is not too great for them; holes are also available for noting the length of flame or for taking other observations. At the present time experiments are being made with a semi-bituminous coal, of which it is necessary to take about 35 simultaneous gas samples, which must be analyzed not only for CO_2, CO and O, but also for hydrogen and hydrocarbons. When coals of the high-volatile bituminous class are used it will probably be necessary to materially increase the number of such samples.

In connection with the preliminary or calibration work on this long combustion chamber some interesting observations were made as to the relative value of an air space and of asbestos as a means for heat insulation. These observations are set forth in Bulletin No. 8, of the Bureau of Mines, entitled, "The Flow of Heat through Furnace Walls."

In addition to this long combustion chamber work the bureau is called upon to make tests or conduct special investigations for other bureaus or departments in their own plants.

Some special problems along steaming lines have also been taken up at the testing station, among which is a study of the effect of certain features of furnace construction upon the smoke production in a hand-fired, return-tubular boiler furnace. This work has not been entirely completed but the results so far obtained indicate that a high-volatile coal can be burned at ordinary rates of combustion in such a furnace if steam jets are used for a short time after firing, without violating the smoke ordinances.

The policy of the bureau now is to carry on experimental work for the purpose of studying fundamentals.

It is essential that the basic principles of the combustion processes of fuels be more definitely determined and it is believed that the tests now in progress will bring to light much information along these lines.

Electrical Department

Especially conducted to be of interest and service to the men in charge of the electrical equipment

Correcting Low Power Factor with Synchronous Motors

It has been pointed out by several writers in POWER how the bad effects of a heavy "lagging-current" load can be offset by the use of synchronous motors running on the same line, with their field magnets overexcited. When a synchronous motor is thus operated, it takes from the line a "leading" current which offsets, to a greater or less extent, the lagging current caused by induction motors and other highly inductive apparatus and causes the current which actually passes through the generator windings at the station to lag very much less than it would without the synchronous motors in circuit.

This application of the synchronous motor is increasing very rapidly and a great many such installations have already been made. For example, two machines of 1650 kilovolt-amperes capacity each are in operation in the Buffington substation of the Illinois Steel Company, where they work on the low-tension circuit which supplies an induction motor load in the mills of the Universal Portland Cement Company. The good effects of these machines are indicated by the following readings taken at the generating station and the substation simultaneously:

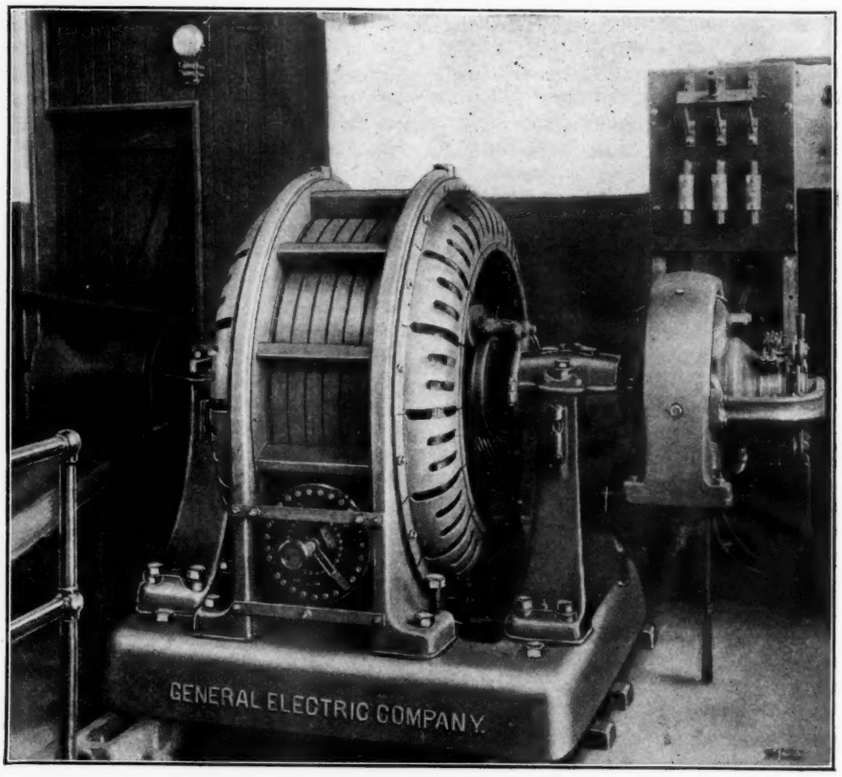
	Motors Off	Motors On
Kilowatts indicated at main station busbars	6100	6400
Kilowatts indicated at substation busbars	5800	6150
Voltage at substation low-tension busbars	450	475
Power factor at main station busbars	74%	91.7%

The full-load *current* was maintained in the low-tension circuits of the substation with the synchronous motors on and off.

In the Buffington substation the synchronous motors do not drive any load, but it is not necessary to have them run free. A machine installed for the same purpose in the factory of the Chalmers Motor Company, Detroit, is utilized to drive an air compressor in addition to correcting the power factor of the power circuit. Before the synchronous motor was put in, the voltage drop in the low-tension circuit was so great that a 68-kilowatt boosting transformer had to be installed to keep the voltage high enough for the satisfactory operation of the induction motors which drive the factory machinery. The power factor was so bad, however, that it was found advisable to put in the synchronous motor; its operation has raised the power factor from 68 to 95 per cent. and correspondingly improved the regulation of the whole system. This machine is illustrated in the accompanying picture.

The usefulness of the synchronous motor as an improver of the power factor of a circuit or system is not restricted to long lines nor to extensive distribution systems. A 300-kilovolt-ampere machine is in use at the Saxony Worsted Mills, Bemis, Mass., in the same room with the generators which supply the system, which is all located within a radius of a few hundred feet. The total generating equipment is rated at 1050 kilowatts and supplies current to induction motors almost exclusively. The load variations are such that before the synchronous motor was installed the average power factor of the system was only 64 per cent.; the use of the motor has raised the average power factor to about 85 per cent. This motor runs entirely free.

Dozens of similar cases could be cited, but the three here outlined are sufficiently typical to indicate the real practicality of using synchronous motors for counteracting the objectionable effect of induction motors on the power factor of a system. In laying out new motor-driven factories and industrial establishments using large numbers of motors, it should be the policy of the directing engineers to arrange for driving as many machines by synchronous motors as possible, and this will undoubtedly become a recognized plan of design. Machines that can be operated continuously at a reasonably steady load and those which can be shut off without having to shut down the motor can be as conveniently and efficiently driven by synchronous motors as by the other kind.



SYNCHRONOUS MOTOR OF 300 KILOVOLT-AMPERES CAPACITY DRIVING AN AIR COMPRESSOR AND SERVING AS A ROTARY CONDENSER

For the illustration and the facts relating to the three installations briefly described herein we are indebted to the *General Electric Review*.

The Maintenance of Electric Circuits

By W. T. Ryan

Where the quality and design of the apparatus and accessories for the generating plant and the substations have been selected with regard to their requirements and are afterward intelligently operated, almost all of the troubles which now affect the continuity of service may be charged to the line.

Though the maintenance of overhead lines is comparatively easy as a rule, owing to the ready accessibility of such lines for inspection at all times, the exposure of the lines to the action of the elements subjects them to a high rate of depreciation. Continuity of service cannot even be approximated with overhead lines in a distribution system of considerable extent. No matter what precautions are taken or how good the construction, the service is sure to be interrupted at almost any point of the system at one time or another.

The principal causes of trouble are open circuits, grounds, short-circuits and those circuit changes which produce oscillations. These are directly or indirectly traceable to weak insulators, defective pins, burning of poles, lightning, etc.

The various forms of lightning arresters and the methods of locating grounds, crosses and short-circuits, have been covered by the writer in previous articles.*

Lightning arresters should be installed on all main lines for the protection of station apparatus and transformers. All branch lines should be protected by at least one set of arresters. Where the line is long or there are several transformers to be protected there should be several arresters and these should be properly grounded, because poor grounding renders the operation of the arrester uncertain and often defeats the purpose of its use. Regular inspection of all lightning arresters should be required and additional inspections should be made after every heavy electrical storm.

The choice of insulators depends principally on the voltage, and their mechanical strength and the locality through which the line passes should be given very careful consideration. In a locality where, for example, fog occurs at the same time or alternately with dust, the insulators are sure to develop trouble. An examination of a large number of insulators which had to be removed from a certain line showed that the dust with which they were coated was thickest in the still air spaces and was as thick on the vertical as on the horizontal surfaces. Where fog and dust do not occur together there is not nearly so much trouble with the insulators. In some cases it may be necessary to shut down one to three times during the dust season and clean the insulators. Insulators tested for 120,000 volts, water test, for one minute, have been known to give trouble in less than a month after being placed on a 40,000-volt line. Other types which had stood 40,000 volts, water test, for five minutes, have been found unsatisfactory for 13,000-volt city service. This merely shows that insulators which are successfully tested at abnormally high voltages before they are put into service may cause trouble when on the line.

Conditions of transmission may be considered good if, for continuous use only, 1 per cent. of the insulators have to be replaced each year.

It was found that where the insulators were giving trouble on a line operating at 40,000 volts, reducing the pressure to 30,000 volts did not produce a corresponding or an immediate decrease in the number of insulators broken per month. The total number remaining seemed to be in more or less of a weakened condition, and they continued to break down after the line pressure was reduced, though after a certain period of time the breakage per month was reduced.

The charring of wooden pins is a source of much trouble on high-tension lines. In some localities the leakage over dust-covered insulators will destroy the pins in from one to three months. This may be remedied by placing a metal short-circuit around the pin, though a better plan is to use metal pins. The initial cost is only about 1¾ times that of wooden pins, and they are cheaper in the end because the cost of maintenance is practically nothing. Mold on the thread of wooden pins, so often noticed where a line passes through a marshy place, can be avoided only by the use of metal pins.

The service given by wooden pole-line construction is subject to interruptions by falling and burning poles. The decay of poles can be greatly lessened by continual and thorough inspection.

The old idea that poles of a kind of wood suitable for the soil in which they are set should last from 15 to 20 years has caused much serious trouble.

Engineers are very often prevented from buying poles early enough because of the interest charges on them from the day they would be paid for until the time the wires are strung. The result is that the poles are put in green, and unless they are treated later on they will soon decay. Whenever possible, seasoned poles should be obtained. Their life will be much increased by treating the butts with creosote before setting them. Green poles, however, should not be creosoted before being set. The butts should be treated after the first dry season and retreated about every second season thereafter, depending on the material used and the condition in which the pole is found. This after-treatment may be carried out by digging away the earth from the pole for about 18 inches below the ground level and treating the pole surface up to a point about 18 inches above the ground. The ground level should then be raised by banking earth around the pole. The cost of this treatment will usually be considerably less than one dollar per pole. At the same time the butts are treated the pole tops, gain cracks and ends of the arms should be painted.

If the methods just outlined are carefully followed, a wooden pole line will last about 25 years.

The burning of poles at the ground has caused many interruptions, even where the line was patrolled every day. The remedy is simply a question of persistence and expense in keeping the right-of-way cleared of all growth. Even with a wide right-of-way kept cleared, the wind may carry heat and sparks from a fire to the line. Several cases are on record where the heat from a forest fire along a pole line was not great enough to harm the poles or cross arrows, but did cause large numbers of the glass insulators to crack and fall to the ground. Porcelain is less affected by heat than is glass and it is more durable mechanically.

Underground Lines

Underground lines are relieved of most of the troubles that beset overhead lines; therefore, continuity of service may be more nearly approached. Sleet storms, high winds, in fact, nearly all causes of breakdowns in an overhead system, are harmless when the wires are underground. The maintenance of underground lines installed according to approved methods is very simple and the necessity for repairs much less frequent than on overhead lines. However, when trouble does occur it is usually of such a character as to require more expense and more time to make the repairs.

Water is the arch enemy of underground lines, and some method of draining a conduit is always necessary. Very often the ducts are laid at a slight slope toward the manholes and the water allowed to gather there is pumped out occasionally or, better still, is carried off by connections to the sewer. If no water can enter the conduit except the moisture in the air, it is unnecessary to have a sewer connection.

Gas sometimes penerates the conduits through the walls of the manholes and even through the ducts themselves when there are gas leaks nearby. In New York City so much trouble was experienced from gas and water that it was found necessary to connect the manholes by 6-inch pipes through which a current of air is continually blown. This

*November 10 and November 17, 1908, and April 5, 1910.

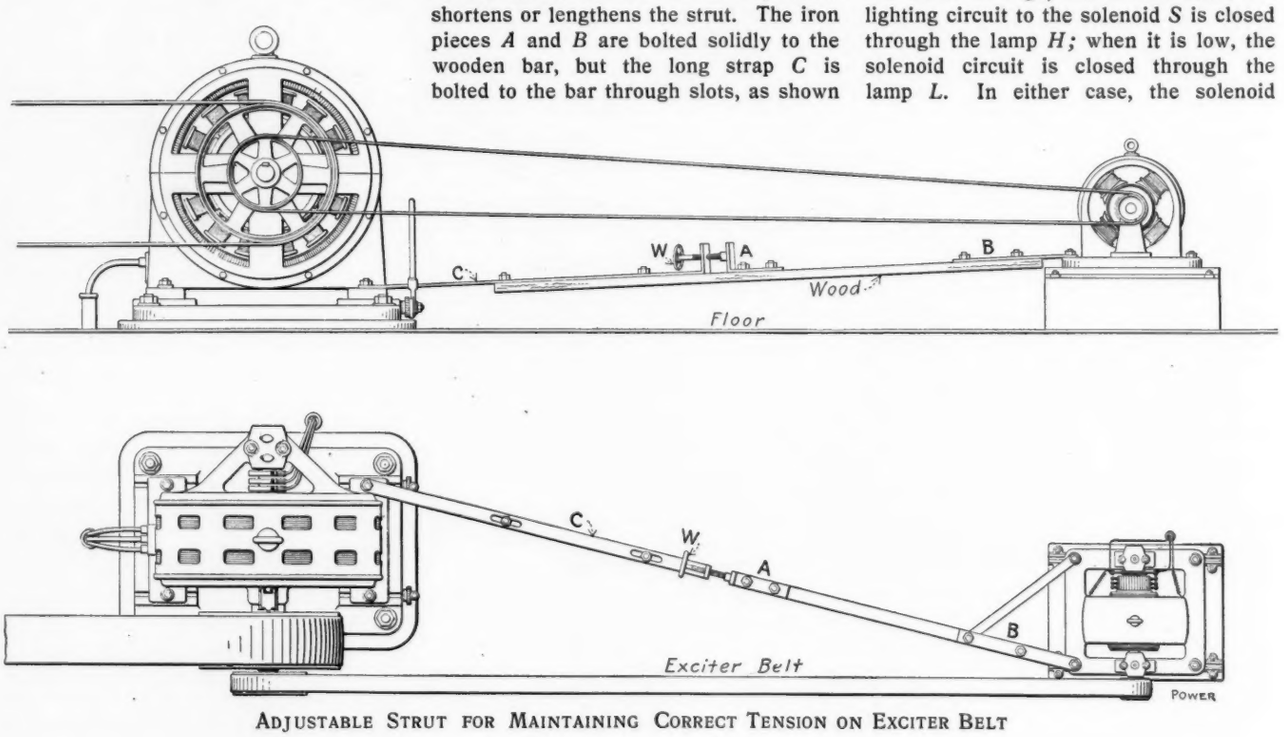
drives out the gas and dries up the water deposited by condensation. Water from the street is kept out by the use of perfectly tight manhole covers. This system is, of course, very expensive and cannot be considered unless a large number of ducts is laid. Ordinarily, the gas can be removed by ventilation through the covers themselves by simply piercing them with holes. Auxiliary pipes leading up to the tops of neighboring buildings are also advantageous.

The failure of the insulation of cables near points where connections are made between overhead and underground lines is often a cause of trouble (especially where the underground lines are short) from lightning. Lightning arresters should be provided near the cable poles. Where the underground system extends over a large area, however, this trouble is not so frequently experienced.

LETTERS

Adjusting a Belted Exciter

The exciter which supplies the field winding of an alternator in our plant is belt-driven from a pulley on the end of the alternator shaft. Consequently, when the alternator is shifted on its base to tighten the belt, the exciter must be adjusted on its base also, in order to keep its belt at the right tension. In order to avoid the bother of adjusting the two machines on their bases by turning the two adjusting screws a little at a time alternately, I have rigged up a distance strut between the alternator and exciter frames as shown in the accompanying sketch; with this arrangement the exciter is kept at the same distance from the alternator while the latter is being adjusted on its base. Whenever it is necessary to adjust the tension of the exciter belt independently, that is done by means of the handwheel and screw *W*, which shortens or lengthens the strut. The iron pieces *A* and *B* are bolted solidly to the wooden bar, but the long strap *C* is bolted to the bar through slots, as shown in the plan view; the bolts through these slots are slackened when the length of the strut is to be changed and set down tight after the adjustment is made.



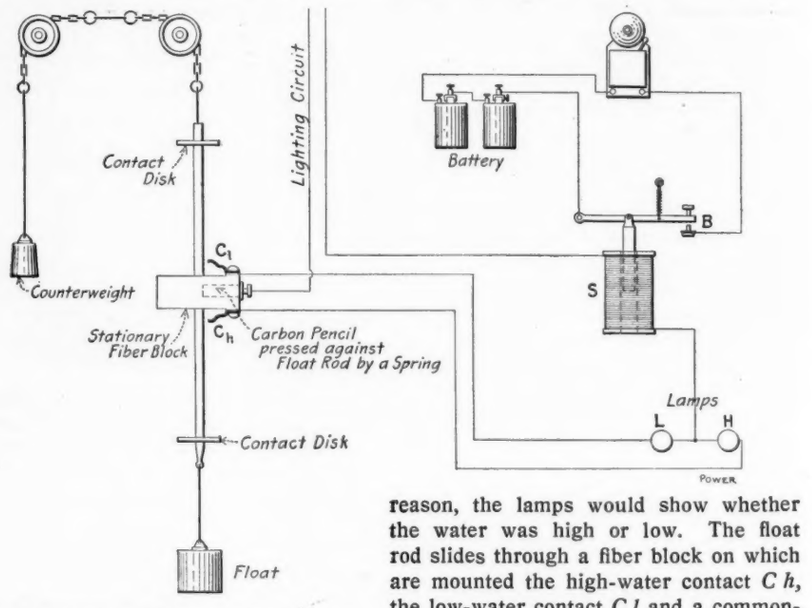
ADJUSTABLE STRUT FOR MAINTAINING CORRECT TENSION ON EXCITER BELT

CHARLES H. LYNCH.

Lewes, Del.

Water Tank Signal System

The alarm illustrated here is as reliable as one could be made, because if the alarm bell did not ring for any reason, the lamps would show whether the water was high or low. The float rod slides through a fiber block on which are mounted the high-water contact *C h*, the low-water contact *C l* and a common-return contact consisting of a carbon pencil pressed lightly against the rod by a spring.



MR. WOOLMAN'S WATER-TANK SIGNAL SYSTEM

The system is entirely automatic, no switch manipulation being required. When the water is high, the circuit from the lighting circuit to the solenoid *S* is closed through the lamp *H;* when it is low, the solenoid circuit is closed through the lamp *L*. In either case, the solenoid draws its plunger down and closes the bell circuit at *B*. When the solenoid circuit is open, the contact at *B* is kept open by the spring above the lever.

N. E. WOOLMAN.

Danbury, Ia.

Gas Power Department

Everything worth while in the gas engine and producer industry will be treated here in a way that can be of use to practical men

The Effect of Varying the Supply of Steam to a Gas Producer*

By E. A. Allcut

The experiments recorded in this paper were performed with a small gas producer at the University of Birmingham. The chief object was to determine the influence of varying quantities of steam on the general working and efficiency of a producer plant of small size. The supply of air to the producer was, therefore, kept as nearly constant as possible in all the trials, while the steam supply was varied from nothing to a maximum of 1.14 pounds per pound of coal. In order to avoid complication and to eliminate all uncertainties of measurement which must necessarily arise from the presence of tar and volatile hydrocarbons, as well as to obtain a fuel as nearly approximating to pure carbon as possible, anthracite pea coal was used throughout the trials.

The steam required for the process was generated within the producer, so that the general conditions closely resembled those under which a modern suction plant works; the sole exception being that the draft was produced by a fan instead of by engine suction. The conditions were thereby kept fairly steady throughout each trial. A good deal of uncertainty seems to exist among the makers and users of gas producers respecting the amount of steam that is required to give maximum efficiency and best all-round working, and it was hoped that these trials would clear up a good deal of that uncertainty. A series of similar trials were performed in 1906 by Messrs. Bone and Wheeler,† on a 2500-horsepower gas plant. It was felt, however, that the conditions under which those trials were performed were vastly different from those under which most of the smaller plants work, and that it was necessary to repeat them on a small plant with nonbituminous fuel, to gain a more exact idea of the influence of steam upon producers of small capacity.

Reactions in the Producer

The true nature of the combustion of solid carbon is still, among scientists, a vexed question. Some chemists hold that with excess of carbon the combustion proceeds in two stages: first of all with the production of carbon dioxide,

$$C + O_2 = CO_2 \qquad (1)$$

and then with the reduction of the dioxide on further contact with carbon,

$$CO_2 + C = 2\,CO \qquad (2)$$

Others maintain that the combustion proceeds in a single stage, direct to carbon monoxide,

$$2\,C + O_2 = 2\,CO \qquad (3)$$

At the bottom of a gas generator, however, the carbon is never in excess, so that the author is of opinion that the first two reactions probably take place within the generator. However this may be, the final chemical and thermal results of the combustion are the same in each case.

When steam is admitted with the air it may react on its own account with the carbon in the following ways:

$$C + H_2O = CO + H_2 \qquad (4)$$

$$C + 2\,H_2O = CO_2 + 2\,H_2 \qquad (5)$$

Both of these reactions absorb heat, the former to the extent of 4300 B.t.u. per pound of carbon, and the latter to that of 2820 B.t.u., so that each of them has the practical advantage of reducing the temperature of the producer. It has been found* that at a temperature of 1112 degrees Fahrenheit and under, the latter reaction takes place, but at temperatures above 1832 degrees Fahrenheit, reaction (4) is more likely to occur. At temperatures between 1112 and 1832 degrees, the two take place simultaneously, the predominance of either being entirely a function of the temperature. It is clear that as equation (4) gives the richer gas and the greater absorption of heat, it is advisable to maintain the highest temperature consistent with practical working. The high percentage of CO_2 in Mond gas is due to the predominance of the reaction expressed by equation (5), which results from the low temperature and excessive steam supply necessary for ammonia recovery. This latter consideration does not enter into the practical working of plants of less than 2000 horsepower, so that in small plants the steam supply can be cut down to any point consistent with the nonformation of clinker.

The actual conditions inside the generator are by no means as simple as would appear from the preceding reactions. When CO and steam are both present in a gas producer, the following reversible reaction may be set up:

$$CO + H_2O \leftrightharpoons CO_2 + H_2 \qquad (6)$$

This reaction, which takes place at temperatures above 932 degrees Fahrenheit, also depends for its balance upon the temperature. At high temperatures (1832 degrees Fahrenheit) the left-hand side predominates and at low temperatures carbon dioxide and hydrogen are formed. At any temperature between 932 and 1832 the product of the percentage volumes of CO and steam bears a constant ratio to that of the CO_2 and hydrogen. Oscar Hahn† gives the values in Table 1 for this ratio at different temperatures. As the ratio rises with the temperature, the addition of steam, lowering the temperature, will cause a change in the opposite direction. The oxidation of CO, however, liberates heat and raises the temperature, thereby tending to check the action. The conditions for stability are always in the direction of high temperature and the consequent formation of CO.

TABLE 1

Temperature	$\frac{CO \times H_2O}{CO_2 \times H_2} = K.$	Temperature	K.
786 C. (1447 F.)	0.81	1086 C. (1987 F.)	1.95
886 C. (1627 F.)	1.19	1205 C. (2201 F.)	2.10
986 C. (1807 F.)	1.54	1405 C. (2561 F.)	2.49

Reaction (2) also is a reversible reaction and depends on the temperature. At 1790 degrees Fahrenheit, Boudouard‡ found that the percentages of CO and CO_2 in equilibrium with solid carbon under atmospheric pressure were 99 and 1 respectively; while at 1497 degrees

*Abstract of a paper read before the Institution of Mechanical Engineers of Great Britain.

†*Journal*, Iron and Steel Institute, 1907, No. 1.

*"Producer Gas," Dowson and Larter, page 55.

†*Zeitschrift für Physikalische Chemie*, 1903.

‡*Annales de Chimie et de Physique*, 1901.

they were 90 and 10, and at 1090 degrees they became 20 and 80. Generally, then, increase of temperature favors the formation of CO, giving richer gas and higher efficiency, and at lower temperatures a higher proportion of CO_2 is obtained.

The steam supply to the producer has then an important effect, as it controls the temperature at which these reactions take place. If the steam supply is increased above a certain amount per pound of carbon, the temperature and efficiency of the plant both fall. If, on the contrary, the supply is cut down too low, the temperature rises, gives bad working

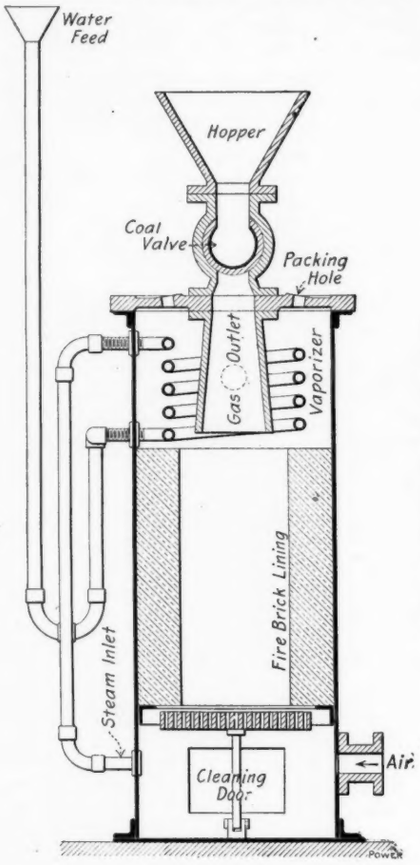


FIG. 1. THE GENERATOR

and increased heat losses and yields a poor gas. There is then clearly a certain proportion of air and steam that will give maximum efficiency, and it was one of the objects of these trials to find that point.

DESCRIPTION OF EXPERIMENTAL PLANT

The entire plant was made in the workshops of the University of Birmingham, and is illustrated herewith. The generator, Fig. 1, consists of a wrought-iron shell lined with firebrick. The inside diameter of the lining is 10 inches and its hight 25 inches. The joint between the bottom of the lining and the wrought-iron angle ring that supports it was carefully made with fireclay and the space between lining and shell rammed with the same material. Notwithstanding these precautions, some of the air found its way up to the top of the generator through cracks in the lining and produced a certain amount of CO_2 by combustion of CO. This accounts for the high percentage of CO_2, in the earlier trials, and partly for the low calorific value of the gas.

The fuel level in the generator was kept as constant as possible by the distributing bell shown in Fig. 1. The conical coal valve allows the coal to be charged into the producer without escape of gas or influx of air. The grate consists of a grid of wrought-iron bars, with spaces of ¼ inch between them, so that no coal can fall through without burning. The grid is hinged at one end and supported by a movable bar at the other, so that it can be dropped at will and the generator emptied through the cleaning door. The vaporizer consists of a coil surrounding the distributing bell in the top of the chamber. The steam formed at the expense of sensible heat from the gas passes out at the top of the coil and is conducted by a lagged pipe to the ashpit.

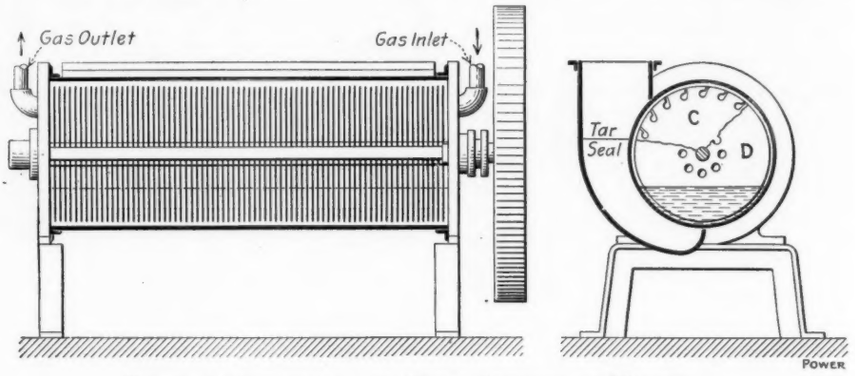


FIG. 2. LONGITUDINAL AND CROSS SECTIONS OF WASHER

The washer, Fig. 2, is of novel construction. It consists of a cylindrical shell, 18 inches in diameter by 48 inches long, closed at the ends and traversed by a shaft strung with thin disks of 17 inches diameter. This shaft is rotated at 76 revolutions per minute. The disks are alternately pierced at the edge and the center, as shown at *C* and *D*, so that the gas is forced to pass zigzag fashion from one end of the washer to the other. The washer is partly filled with water which is picked up by the small vanes on the disks marked *C* and dashed intimately into contact with the gas. The large area of wetted surface thus presented to the gas makes this type of washer very efficient as a cooler.

The plant layout is shown in Fig. 3 as arranged for a trial. The air was supplied by a motor-driven fan and its volume was ascertained by measuring the drop in pressure down a narrow tube (9 feet long by 1 inch in diameter). The differential gage used for this purpose is shown in Fig. 4. The large cross-sectional areas at the top give a large movement of the meniscus between the paraffin and water for a small difference in pressure. The movement of the meniscus was observed on a scale engraved in a mirror at the back of the gage, and a calibration curve prepared by putting the tube in series with a standard gas meter and observing movements of the meniscus for various rates of gas supply. The same method was used for measuring the gas produced. The amount of air was adjusted to the required value by opening or closing the escape valve in the air pipe. The temperature and pressure of the air supply were also observed.

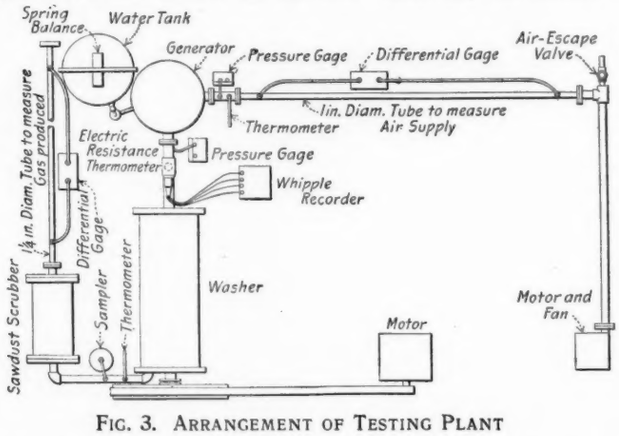


FIG. 3. ARRANGEMENT OF TESTING PLANT

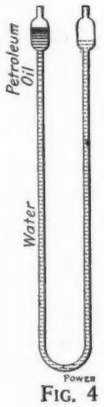


FIG. 4

The water was fed into the vaporizer from a tank supported above the producer by a spring balance, from the readings of which the weight and regu-

larity of the feed were ascertained. The temperature of the water feed was taken at regular intervals.

The coal was weighed out in lots of 7 pounds, a sample being taken at each weighing. Each trial was started with the generator full of coal and a level in the hopper was marked. The weighed lots of coal were fed into the hopper in each case as soon as this level was reached and at the end the surplus coal was taken out and weighed, so that the quantity used during the trial and the regularity of feed were accurately known.

The reason for the adoption of so small a plant was to enable us to test it in a short time. The actual duration of each trial was 4 hours, but the plant was run for some 3 or 4 hours in each case before any readings were taken, in order to get conditions steady before the trials were commenced. The steadiness of the conditions was judged from the constancy of temperature of the gas issuing from the producer. At the end of each trial an electric-resistance thermometer was introduced into the generator through one of the poke holes and the temperature was taken at the grate and at intervals of 3 inches upward from the grate to the top of the generator.

All readings were taken at intervals of 15 minutes. The gas samples were taken over mercury at intervals of 30 minutes and carefully analyzed in special apparatus. The volume of CO present was obtained not by absorption in cuprous chloride but by explosion with air. The CO, hydrogen and methane were all exploded together and the contraction, CO_2 formed and oxygen used were measured in the usual way. This method gives three equations from which the respective volumes of the three constituents of the gas can be determined.*

The heat value of the coal was in each case ascertained by combustion in a Mahler bomb calorimeter. The heat value of the gas, the heat lost in the washer and the water vapor entering the producer with the air were calculated from the observations. The heat values used for this purpose were:

CO = 340.9 B.t.u. per cubic foot
H_2 = 343 B.t.u. per cubic foot
CH_4 = 1067 B.t.u. per cubic foot

The efficiency was in every case calculated from the calorific value of the raw coal and the higher heat value of the gas, and includes the heat required to vaporize the water feed. The heat in the gas is also expressed as a percentage of the heat in the coal, for the sake of comparison.

Deductions from Tests

The first noticeable point in these results is to be found in Fig. 5, which shows that the percentage of hydrogen in the gas did not increase with an increase of water fed into the fuel bed when the water exceeded 0.75 pound per pound of coal. This corresponds, as shown in Fig. 6, to the decomposition of about 72 per cent. of the total weight of water fed to the fuel bed. This result is very important, as it shows that the maximum amount of steam that can be decomposed by anthracite at a temperature of about 1832 degrees Fahrenheit is about 0.535 pound per pound of coal; see Fig. 6. It follows that there can be no advantage, but only loss, in pushing the steam supply much beyond ¾ pound of steam per pound of coal in small anthracite gas producers. If this rate is greatly exceeded, the increased supply of steam merely takes heat from the producer and loses it in the washer. Large quantities of steam are not necessary for the prevention of clinkering. The shallow fuel bed in the producer tested by the author, however, with its consequent high mean temperature, resulted in the advantageous use of a higher proportion of steam than could be economically used in a producer having a deeper fuel bed.

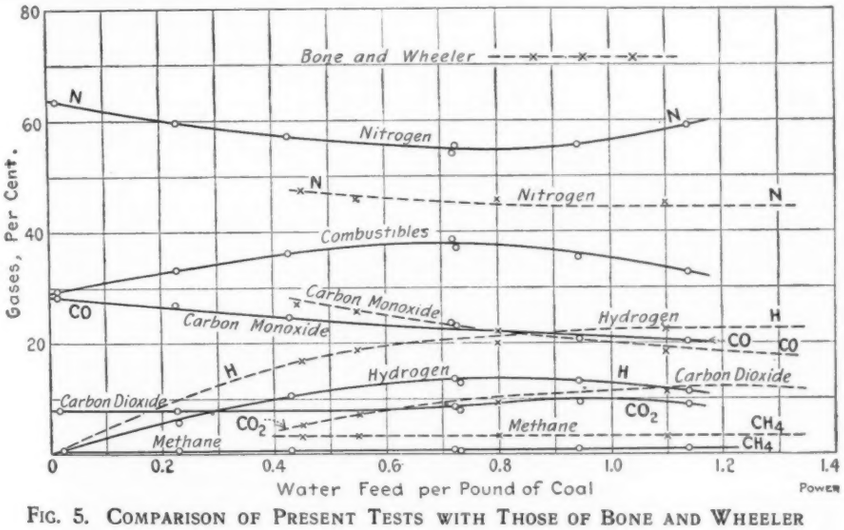


Fig. 5. Comparison of Present Tests with Those of Bone and Wheeler

The low percentage of hydrogen in the gas throughout these trials was due to the large quantity of air which had to be used to keep the vaporizer at a sufficiently high temperature to supply the necessary amount of steam, owing to the inefficiency of the steam coil. This resulted in a high ratio of air to steam and the consequent presence of a large quantity of nitrogen in the gas.

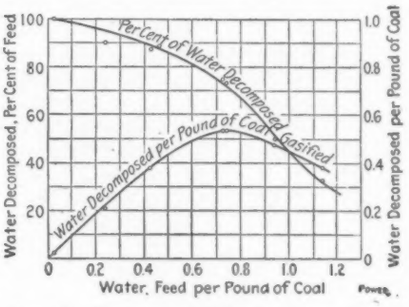

Per Cent of Water Decomposed, Gasified
Water Decomposed per Pound of Coal Gasified
Water Decomposed, Per Cent of Feed
Water Decomposed per Pound of Coal
Water, Feed per Pound of Coal
Power

Fig. 6. Effect of Water Feed Rate upon Decomposition

Combustion of Carbon

The most significant result of these trials is that the percentage of CO_2 remained practically constant, in spite of the increasing feed of steam to the fire. The high content of CO_2 in the trials where little or no steam was supplied was due, as explained, to a leakage of air. Eliminating the 7 per cent. of CO_2 in the first trial as due to this cause, it is found that the maximum rise during the whole of the trials is merely about 2.5 per cent. It would naturally be expected that the increased supply of steam would diminish the temperature inside the generator and result in the production of increasing quantities of CO_2, from reactions (5), (6) and (7). This is admirably shown in the trials of Messrs. Bone and Wheeler, where the CO_2 (shown dotted in Fig. 5) rose from 5.25 per cent. at 0.45 pound of water per pound of coal to 13.25 per cent. at 1.55 pounds of water per pound of coal.

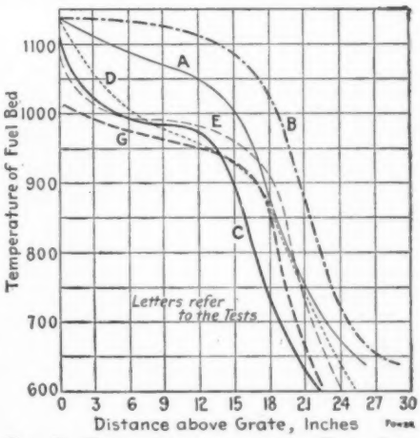


Fig. 7. Temperatures in the Fuel Bed

Why does not the same rise occur in the author's experiments? It seems at

*The equations are as follows:

$\frac{1}{2}CO + \frac{1}{2}H_2 + 2CH_4 =$ Oxygen used
$\frac{1}{2}CO + \frac{3}{2}H_2 + 2CH_4 =$ Contraction
$CO + CH_4 = CO_2$ formed

first sight that these experiments contradict the theory laid down at the beginning of this paper—a theory supported by experimental evidence in the tests of Messrs. Bone and Wheeler. The contradiction, however, is only apparent. At the end of each trial the temperature of the fuel bed was taken at equidistant levels from the grate to the top of the bed. Although the temperature curves thus obtained (see Fig. 7) are somewhat erratic, as might be expected, there is one characteristic which is common to all. The temperature keeps fairly constant at about 1832 degrees Fahrenheit (1000 degrees Centigrade) for a distance of about 18 inches upward from the grate and then falls rapidly to about 1112 degrees Fahrenheit (600 degrees Centigrade) in the next six inches or so. In the first 18 inches, then, the combustion of the carbon is obviously taking place and all the heat is developed. Above this point the steam begins to affect the temperature and causes it to fall with extreme rapidity.

Now, as has been explained, at a temperature of 1832 degrees Fahrenheit, no CO_2 can exist in contact with excess of carbon. The large excess of oxygen at the grate causes the carbon to burn to CO_2 with the evolution of large quantities of heat and the maintenance of a high temperature. The excess air burns [?] higher up in the generator and maintains the temperature, but farther away from the grate, the reduction of CO_2 to CO and the endothermic steam reactions begin to have the predominating effect on the temperature. The first 18 inches, then, may be termed the zone of active combustion where, owing to the high temperature, the gases produced are almost entirely CO and hydrogen. There is above

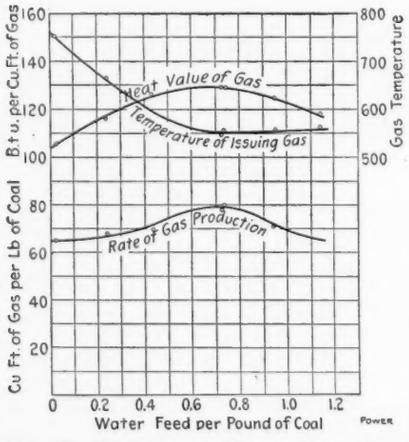

Cu Ft. of Gas per Lb of Coal
B.t.u. per Cu.Ft. of Gas
Gas Temperature
Heat Value of Gas
Temperature of Issuing Gas
Rate of Gas Production
Water Feed per Pound of Coal
POWER

FIG. 8. EFFECT OF WATER FEED RATE UPON GAS MADE

this about 6 or 7 inches of fuel bed in which the temperature is rapidly falling. This would have its due effect in re-forming CO_2 by reactions (5), (6) and (7) if it were not so thin. The shallowness of this comparatively cool layer of fuel does not allow sufficient time for these reactions to seriously affect the composition of the gas and the efficiency of the producer. This shows that in a generator which has a shallow fuel bed, provided there is no leakage, there need not be more than 2 or 3 per cent. of CO_2 in the gas. If more than this quantity is present, it is due either to leakage or to the use of too great a quantity of air for the size of the producer. In the latter case, the velocity of air through the fuel is high and some of the CO_2 formed by combustion in the fire zone escapes reduction to CO. The depth of the fuel bed should therefore be cut down to the lowest value consistent with practical working.

In large generators a deep fuel bed is necessary, as the larger sizes of coal used in them do not pack as close as the smaller pieces and the distribution of air across the section of the fuel mass is apt to be irregular. In such cases it might even pay to have a secondary air supply admitted some distance above the

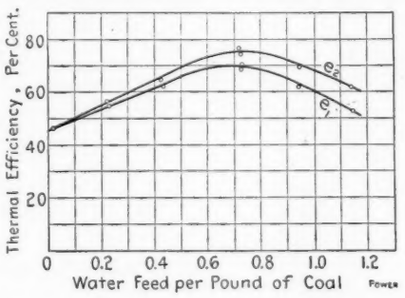


FIG. 9. WATER FEED AND HEAT EFFICIENCY

grate. This would have the effect of introducing another zone of active combustion, in which the heat evolved by the combustion of the secondary air to form carbon monoxide would be available for reducing the CO_2 coming from the grate. The depth of the cool layer of fuel above the active combustion zone would thus be reduced and the re-formation of CO_2 according to the reaction expressed by equation (6) would be greatly diminished.

HEAT VALUE OF THE GAS

The heat value of the gas is very low throughout, as shown in Fig. 8. This is partly due to the low percentage of hydrogen which is the outcome of the high ratio of air to steam. The nature of the fuel also is accountable for the very low percentage of CH_4 which has a great influence on the heat value. It is noticeable that the percentage of combustibles in the gas regularly increases until 0.7 pound of water per pound of coal is reached, and then decreases again. The heat value also reaches maximum about this point.

EFFICIENCY

The efficiency of the producer is taken as the ratio between the heat generated which does useful work outside the producer itself and the total heat in the coal used during the same period.

It will be evident from Fig. 8 that the maximum yield of gas occurred at a water feed of about 0.75 pound per pound of coal. This is near the point where the maximum percentage of hydrogen was

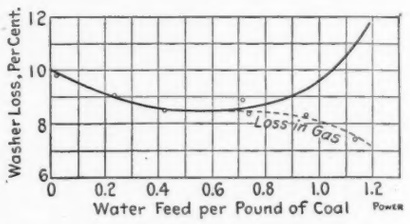


FIG. 10. WATER FEED AND WASHER LOSS

obtained, and where the heat value of the gas was highest. It follows, therefore, that the efficiency of the producer reaches its maximum at this point. The lower curve e_1, Fig. 9, gives the ratio of the heat per hour in the gas produced to that in the coal used, expressed as a percentage. The higher, e_2, includes the heat necessary to vaporize the water supply; the latter represents heat that would otherwise be lost in the washer and as it is taken from the generator it should be credited to that source of supply. The higher value, e_2, is, therefore, the true efficiency of the producer.

The temperature of the gas leaving the generator is shown in Fig. 8. The highest temperature was attained in trial A (in which no water was fed into the vaporizer), being about 750 degrees. A steady fall was maintained with the increase in water feed until trial D was reached, when the temperature was about 550 degrees; after this, the temperature remained fairly constant.

The washer loss is almost constant from trials A to D, the fall being simply due to the drop in temperature of the gas. After this point, however, it rapidly rises, owing to the sensible and latent heat carried over by the surplus steam. The dotted line, Fig. 10, shows the heat carried away by the gas alone. The sharp upward slope of the latter end of the curve shows the necessity for regeneration where large quantities of steam are used.

The longest electric railroad in Austria is the 40-mile line running from Trient to Male, and it ranks among the long lines in Europe. It was built especially as an electric road, and is narrow gage, using overhead trolley and working on 800 volts direct current. The motor cars have four 50-horsepower motors, one on each axle. Current for the line is taken from the distant hydraulic station of Sarca on 20,000 volts, this being reduced in three substations along the railroad in order to feed the trolley wire. Freight and postal cars are also used.—*Scientific American.*

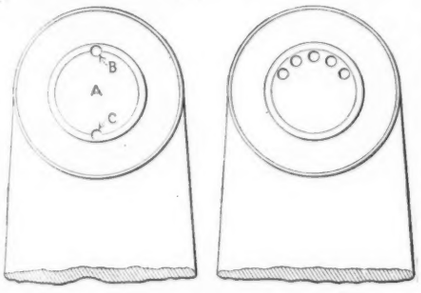
Readers with Something to Say

Practical information from the man on the job. A letter good enough to print here will be paid for. Ideas, not mere words wanted

Pins in Loose Crank Pins

From time to time there have been printed tales of "Loose Crank Pin Repairs" which vary a little in detail, as to how discovered, probable cause, etc., and it has seemed to me about time a change was made in the method of repair, which in each case has been about the same. The practice has been to drive a key half in the pin and half in the eye of the crank. The fact that this key takes the form of a round pin, or pins, driven in or of holes tapped and bolts screwed in, makes but little difference, and "don't do it" seems to me about the proper advice.

Most of these are temporary jobs, to help things along until "we get a chance."



TWO METHODS OF DRIVING PINS IN A CRANK PIN

I have seen a number of such jobs done, and never knew one to pan out tight long enough to pay for the labor spent on it; and if the matter is looked into, it will be plain why the job failed.

For instance, a pin is loose in the eye *A*, and a hole is drilled in both pin and eye, and the pin *B* driven in hard, concentrating the holding strain to the diameter of the pin *B*, which soon works loose. A second pin is driven at *C*, which only makes matters worse by concentrating the holding strain at *B* and *C*, and it is self-evident that this arrangement will not hold; and a triangular arrangement of pins is no better.

In case the holes are tapped and the pins are screwed in, matters are worse, as a few turns of the engine will bed the top of the usually poor fitting threads into each other, and the pin is still loose.

It goes without saying that a proper repair consists of reboring the eye of the crank in line with the shaft and shrinking or driving in a new pin, and until this is done, what is the sense of spoiling the crank and eye and weakening it by a half hole, or series of half holes?

Similar repairs have been made and have held tight in crank eye and shaft ends for a long time, and left things in good order for permanent repairs, as follows:

A series of holes are drilled in the loose pin with the edge of each hole 1/32 to 1/16 inch from the outside edge, and a tight-fitting pin, with a slight taper, driven into each hole, which will expand the face of the crank pin out against the eye while forcing the front side of the pin close against the eye, keeping a large amount of surface in contact with the face. When this pin is removed for permanent repair, the eye is in good condition for reboring and is not permanently weakened by a series of gutters.

B. W. ROBINSON.

Dorchester, Mass.

Makeshift Valve Repair

At an electric-railway power station where I was employed, there occurred an accident to a 500-horsepower cross-compound condensing engine, caused by water in the cylinder.

The condenser is a jet with a vertical, duplex, single-acting pump. Originally this pump was fitted with a piston valve for each cylinder, but one of the piston valves had been broken and a plain slide valve substituted.

Both valves worked on the same stem and the remaining piston valve was made to actuate the slide valve. This burdened the piston valve so much that the pump would frequently stop on account of the valve sticking. I have known this to happen as many as six or seven times a day. By keeping a pinch bar handy and prying the valve stem over the pump would start off again. By this means and the aid of the vacuum breaker trouble was avoided for a long time.

One day, however, the pump stopped once too often, the vacuum breaker failed to operate and the engine was badly damaged. The only remedy applied was a new float to the vacuum breaker. I would not be surprised to hear of the same thing happening again, for the one piston valve is still doing the work of two.

FREDERICK M. PERRAS.

Mansfield, Mass.

Successful Isolated Plant

A good example of economical operation in a small isolated plant, together with a demonstration of the value of accurately kept records covering every detail pertaining to its care and operation was furnished recently when a central-station solicitor submitted to the directors of a club a proposition to light the establishment.

Additions were contemplated doubling the capacity of the existing equipment and necessitating a large increase of the power plant which now furnishes heat for the building, the swimming pool and bath water and light for the whole institution.

The plant consists of a 40-kilowatt 125-volt generator direct connected to an automatic horizontal high-speed engine running noncondensing, and two 50-horsepower horizontal tubular boilers and accessories. Bath water is stored in a tank 25 feet long, and 6 feet in diameter, and it must be kept hot day and night the year round. Certain portions of the building require heating seven months out of the twelve and light is required constantly.

The central-station man proposed to handle the entire lighting load and quoted a rate of 5 cents per kilowatt-hour, or less than half the usual rate. By accepting this proposition the possibility of reducing expense was suggested by replacing the engineer with an unlicensed man who would run the boilers at low pressure merely for heating purposes. Some of the directors of the institution were stockholders in the electric company and every effort was made to rush the matter to an immediate conclusion.

The engineer, however, who was careful and painstaking, had complete records of all facts pertaining to the operation of his plant, covering a period of five years. These included all fixed, operating and maintenance charges as well as detailed accounts of all supplies and repairs, each charged to the proper department. He knew to a quarter of an hour how long the generator had run each day in the year and what had been the output as indicated on the switchboard wattmeter. He had complete information as to the time live and exhaust steam had been used and for

what purpose. In fact, no essential detail was overlooked or slighted and his figures, when presented to the directors, convinced them they could not afford to go outside their own plant for the required service.

The figures for one year's run are as follows:

OPERATING AND MAINTENANCE CHARGES

Engineer's salary	$936.00	
Helper's salary	468.00	
Coal, 420 tons at $3.50	1,470.00	
Water for boilers, 65,000 cubic feet at 7½ cents per 100 cubic foot	48.75	
Total		$2,922.75
Supplies		
Supplies chargeable to steam plant:		
Oil, grease, waste, packing, polish, etc	$73.82	
Supplies chargeable to electric plant:		
Lamps, shades, sockets, fuses, etc	286.68	
Total		$360.50
Removal of ashes		50.00
Inspecting boiler		5.00
Repairs		
Engine, generator, switchboard	$28.90	
Boilers	179.24	
Pumps, tanks and piping	187.66	
Tools and hardware	9.66	
Incidentals	9.04	
Total		$414.50
Interest at 5 per cent., depreciation at 3 per cent. Insurance at 0.5 per cent. on $6,700, first cost of plant.		$869.50
Total		$4,322.25
Extra for electric light from central station:		
2,510 kilowatt-hours at 12 cents		$301.20
Grand total		$4,623.45
Engine Room Log for Same Year		
Engine running (hours)		1,847.25
Generator output (kilowatt-hours)		32,248.00
Exhaust Steam		
Hot-water service (hours)	1,845.50	
Building (hours)	1,361.75	
		3,207.25
Live Steam		
Hot-water service (hours)	2,287.00	
Building (hours)	2,084.50	
		4,371.50
If the entire light load had been purchased at the 12-cent rate the cost would have been (32,248 × 12c.) + $301.20		=$4,170.96
If same were purchased at the new rate of 5 cents, the cost for the entire service would be (32,248 + 2,510) × 5 cents		=$1,737.90
Since the plant is operated for light alone not more than 25 per cent. of the entire time the total operating expense divided by 4 represents the charge to be made for light. $\frac{\$4,322.25}{4}$		=$1,080.56
In favor of the isolated plant $1,737.90 — $1,080.56		$657.34

The absence of certain charges usually included in schedules of this nature should perhaps be explained.

Taxes are rebated.

No supervision or overhead charge may be apportioned to the power plant as the engineer is in complete charge and responsible only to a house committee which serves without pay.

As it is not a manufacturing plant the item of profit is not properly to be included.

The above figures were submitted to the directors and demonstrated to them that light was a secondary consideration, a byproduct of the heating equipment, as it were, where the engine served as a reducing valve between the boiler and the heating system. On the basis of the facts above set forth, new units were installed which doubled the capacity of the initial equipment.

T. D. HAYES.

Cambridge, Mass.

Trouble with Leaking Tubes

In May, 1909, a new boiler was installed in the plant where I am employed. Three months after its installation the tubes began to leak.

The boiler is made with but two sheets and double-riveted lap seams. Below the tubes there are two through stay rods which I believe cause the tubes to leak.

I would like to hear from POWER readers who are operating the same kind of boiler if they too, have trouble with leaking tubes.

C. F. REIMERS.

Vienna, S. D.

Pipe and Fitting Tester

It is necessary to occasionally test pipe fittings and separators for leakage where, fortunately, the city water system has a pressure of 90 pounds per square inch. Heretofore it was necessary to use a pressure pump, but the pump cylinder and plunger were too small to maintain a pressure, due to leakage which occurs sometimes in defective gaskets and temporary bolting. I invented a device which works to the Queen's taste and is a big time saver.

In the cut is shown the whole system attached to a small fitting. The upper portion, handwheel, yoke, stem and valve were taken from a discarded 4-inch globe valve. *B* is a compression cylinder, fitted with a cup leather plunger *C* which is attached to the valve on the end of the stem. *D* is a changeable plate to fit various sizes of flanges and *E* is the fitting to be tested. *D* may be blanked when testing through the inlet pipe *F*.

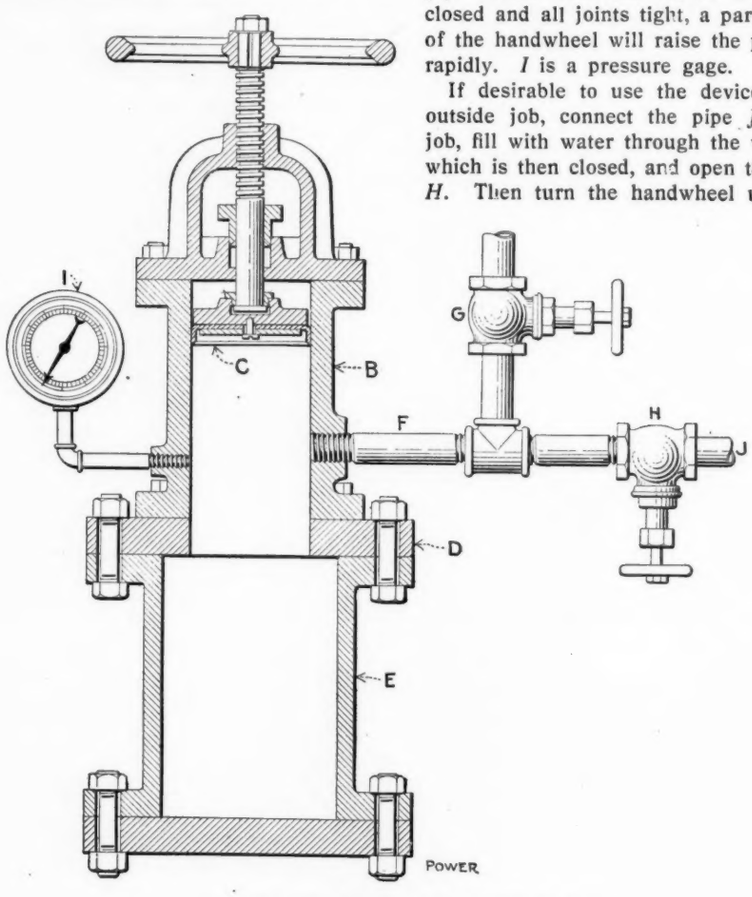
The system is filled with water through the pipe *F* directly from the city supply. Then with the valves *G* and *H* closed and all joints tight, a partial turn of the handwheel will raise the pressure rapidly. *I* is a pressure gage.

If desirable to use the device on an outside job, connect the pipe *J* to the job, fill with water through the valve *G*, which is then closed, and open the valve *H*. Then turn the handwheel until the desired pressure is registered.

If desired to test higher than 300 pounds pressure per square inch, I would advise using a 3-inch cylinder, a larger handwheel or a finer screw.

F. G. CHAMBERS.

Syracuse, N. Y.



SECTION OF PIPE AND FITTING TESTER

Babcock & Wilcox Headers, Tubes and Baffle Walls

I would like to have the opinion of some POWER readers who have had experience with Babcock & Wilcox boilers, on the following questions:

What are the various causes of cast-iron headers cracking, and which style of baffles, vertical or horizontal, causes more header trouble?

With horizontal baffles, does the expansion of the lower tubes tend to push outward on the headers and break them?

Do tubes which spring or bow, create an inward pull on the headers sufficient to crack them?

Should tubes be slightly flared at the ends in the headers or not?

R. E. PAIRMAN.

Philadelphia, Penn.

"Make Good"

At this time when the central station is figuring so largely in the life of the engineer it behooves him to make himself something more than a mere engine runner. He must learn his piece and be able to recite it to the boss just as forcefully as the central-station solicitor, and be so equipped as to carry his point with facts from his own engine room.

This is a condition that the engineer can hope to attain only from the knowledge of the operating conditions of his own plant and by a continual effort to better those conditions. Some hard work is necessary but that is better than losing his position.

A frequent inspection of the boilers both inside and out will in most cases repay the trouble and save considerable on the coal pile, instead of going by the fireman's report that everything is all right. Feed-water heaters scale up and need cleaning as well as boilers, and sludge should be kept out of surge tanks, especially where the suction is on the bottom, as it will make a pump packing last a good deal longer. Make your traps work right and stop your leaky valves; fill up the cracks in the boiler setting and do not wait for the combustion chamber to fill up before you clean it out. Then begin to regulate the firing and feeding. Your method may not be the one your fireman is used to and you may have considerable trouble in getting him broken in, but in most cases he will coöperate as it makes his work easier.

There is another side to the engineer's conditions and possibilities which will raise him in the eyes of his employer from a common employee to an essential factor in the successful operation of the business; he must be able to meet the competition imposed upon him or he will always be haunted by the central-station ghost.

The man who carefully reads his engineering journals, belongs to some engineers' association and benefits by the experience of his brother engineers is the one who usually operates his plant to the satisfaction of his employers and without fear of central-station competition.

By combining the actual experience gained in the engine room with some technical training school or home study, he is in a better position to judge the merits of the new equipment placed on the market, by the use of which he may add greatly to the efficiency of his plant. To be able to lay out plans for changes or additions to his plant without calling in the consulting engineer will also do much toward winning the esteem of his employer. To try to elevate engineering to the rank of a profession I consider the duty of every operating engineer.

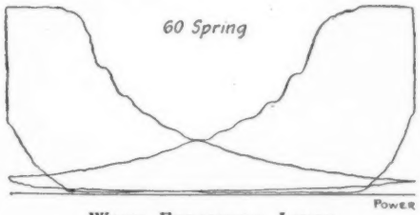
THOMAS H. WATSON.

Chicago, Ill.

Wavy Expansion Line

The accompanying diagram was taken from a 26x48-inch Corliss engine; speed, 90 revolutions per minute; steam pressure, 125 pounds.

The diagrams show a very wavy expansion line. It is not due to a tight piston or vibrating cord, as I have had six different indicators and all produce the same wavy line. This trouble did not show six months ago, but is gradually getting worse.



WAVY EXPANSION LINES

I attribute the wavy line to wet steam, but why should the steam change when no changes have been made in the piping or in the boiler?

I would like to hear from someone who has handled wet steam and learn how he overcame the trouble.

J. W. DICKSON.

Memphis, Tenn.

Twenty-odd years ago, Frank M. Clark and I made an indicator in which the diagram was traced by a spot of light upon a white screen in a darkened room. The movement of the spot was so rapid that the entire diagram stood out brightly, as when one makes an apparently continuous circle in the air by waving a stick with a glowing spark at its end. The diagram was drawn upon a large scale, some four feet in length, and, the beam of light which served as a pencil lever having no inertia and the stiff steel diaphragm which operated it very little, the lines were ordinarily as smooth as those of a waterfall.

The diagram from the little Armington & Sims engine, which ran the shop where we made the indicator, showed, however, a compression line full of fine ripples. We often had the indicator upon that engine and the wavy line always appeared. We conceived all sorts of theories regarding the vibratory action of steam to account for it, and were still floundering in a tangle of nodes, synchronic interference, sound velocity, etc., when I happened, as we sat watching the diagram one evening, to open the drip valve. The compression curve flattened out some, of course, but became smooth. We ground in the drip valve and the compression line remained smooth when it was shut; but by just cracking it and adjusting it back and forth carefully the wavy line could be reproduced. A leak had been there which produced vibrations in some such way as a hole in a fire or the water faucet which makes a deep, organlike rumble when it is adjusted just so. This leak seemed to have no effect upon the other lines of the diagram but a larger leak, such as might occur past a piston, possibly produces the waves which are puzzling Mr. Dickson.

F. R. LOW.

New York City.

Plugged Boiler Nozzle

A new plant was being erected and one of the 4-inch safety valves would not operate. I suggested opening the bypass on the throttle and also on the drips, and drop the pressure on the boiler and then take off the valve, as I suspected that the wooden stopper which is sometimes used in blocking the outlets on boilers during shipment had not been removed before putting on the safety valve.

Sure enough, the next day the engineer showed me the wooden block which had been nicely fitted to the nozzle opening.

D. L. FAGNAN.

New York City.

Sheet Lead Prevented Bearings from Heating

Some time ago one of the journals of a heavy locomotive gave considerable trouble by continually running hot. It was assumed that the trouble was caused by an overhard brass bearing in the box. The box was therefore raised off the journal about ¼ inch, and a piece of thin sheet lead was inserted between the shaft and the bearing surface of the brass bearing. The lead was thus worked into the pores of the brass and no further trouble was experienced.

This plan was tried in several other instances and proved successful.

F. W. BENTLEY, JR.

Huron, S. D.

Questions Before the House

Comment, criticism, suggestions and debate upon various articles, letters and editorials which have appeared in previous issues

The Need of License Laws

I note in the issue of June 20 the editorial and H. Taylor's article commenting on the need of license laws covering the engineering profession.

The writer is a firm believer in such laws as a protection to life and property as well as a means of advancement for the engineer.

Believing that the most direct method of obtaining universal and uniform license laws is by constant agitation on the part of the engineering fraternity, I wish to relate some incidents which came to my notice in a northern New England State where no such laws exist.

I was employed for a short time in a portable sawmill a few years ago before I went to Massachusetts to work my way up as a steam engineer.

This plant was not unlike all portable mills, many of which still exist in some parts of the country, and consisted of a locomotive-type boiler with a slide-valve engine mounted on top with its 6-foot twin flywheels overhanging on either side.

The cylinder, about 10x15 inches, was fastened rigidly to the front course of the shell and the steam chest was connected to the steam dome by an angle throttle valve.

The main bearings were supported by a cast-iron "saddle" riveted to the rear course of the shell, a portion of which had been cut away to allow the crank-pin portion of the saddle to project into the steam space of the boiler.

When in operation a crack would open up under this saddle at every stroke of the engine, first on one edge and then on the other, according to whether the steam was being admitted to the crank or the head end; steam issued from these cracks in generous volumes.

At one time a crack developed in the firebox sheet of the water leg that put out the fire, and the boiler was laid off until patched.

Steam pressure varied from 80 to 100 pounds on a gage that had seen hard usage for a number of years; I do not think it had ever been tested.

On a later visit my attention was called to a leak in a small power boiler which was a combination of locomotive and return flue similar to a Scotch boiler except that it was rectangular instead of circular in cross-section.

As near as I could ascertain, the crown sheet was supported by hollow staybolts from the shell; one of these had evidently become broken as a jet of steam was issuing from the center of it; the engineer was at a loss to know what caused the leak.

These instances are typical of conditions which exist in some States where anyone who can open a throttle is allowed to have charge of high-pressure boilers.

C. B. Hudson.

Lowell, Mass.

Hot Bearings

I read with interest an article in the May 30 issue on using sulphur in hot bearings. Sulphur should not be used in any very hot bearing as a great amount of damage may be done in scoring and cutting the brasses. In my experience when a bearing reaches the condition where no ordinary oil can cool it, the engine should be slowed down at once and the bearing cooled by a stream of cold, clean water to a normal temperature, after which a mixture of castor oil and flake graphite should be made up. Then take away the water and apply this mixture freely; if graphite cannot be had use a powdered sulphur along with the castor oil, but do not use too much, not as much as you would of graphite.

I have cooled down a bearing 30 inches long by 15 inches in diameter in this manner in 25 minutes and run on again for some considerable time.

Some complaint may be made by your superiors for having stopped the machinery for 25 minutes, but from experience we found it wiser to do so than to run the risk of a seized bearing which meant a considerably longer delay. This happened once with me, and someone was near getting, as you Americans term it, "fired."

Having no forced lubrication, we use the ordinary sight-feed drop lubricators; with constant attention I think our figures compare favorably in consumption of oil. It is always wise after a bearing has been excessively heated to lift the shaft, take out the brasses and scrape the hard bearings caused by the heating, and after starting up again apply the same method.

Hot bearings occur at intervals, but someone is to blame and the cause is not hard to find by any intelligent man. Caution your engine man as to what will happen on a second occurrence. Do not stint him in oils; I am sure he will make every effort to prevent a recurrence. Be sure you procure the best castor oil; it will pay in the end.

H. G. Beard.

Mossend, Scotland.

Central Station Failure

Mr. Wise's article in the June 20 issue, "Central-station Failure," does not seem to be founded on facts but more on first newspaper reports of the accident at Philadelphia. If it were true that service was interrupted for several days and such a great loss as $250,000 was entailed on the consumers it would then be well indeed to give at least a passing thought to the proposition of installing so called isolated plants.

To get down to hard facts and leave out all guesswork, at 5:30 a.m., Saturday, May 6, a fire broke out in the station which resulted in the shutting down of one of the main distributing stations, thus depriving consumers in a portion of the large area covered by the company in question for a number of hours, not days.

Long before the fire had been entirely extinguished the work of clearing away the mass of twisted cables and feeders was under way and all possible speed being made to resume the service. The mere fact of one of the main generating stations being temporarily out of commission was no handicap, for the others had plenty of reserve engines and generators to more than make up the loss and at the same time reach the affected district through the large network of interconnecting cables from other stations.

By ten o'clock, just 4½ hours after the fire was first discovered, 30 per cent. of the affected district was connected and before noon 50 per cent. was connected. By evening all but a small percentage of the consumers were receiving service approximating the normal, while all the theaters and other public places were able to conduct their business as usual.

As to the loss sustained by merchants, etc., take the word of one of the largest department stores as a sample of their

feeling of good will in the matter. Although entirely dependent on this service for power the loss sustained through the interruption of elevator service, lighting and minor items was so small compared with the usual amount of sales as to be almost negligible. This is the first time out of over 22 years of continuous service that there has been an interruption of this kind.

MORGAN G. JOHNS.

Philadelphia, Penn.

Burning Fuel Oil

In reference to W. A. Hamlin's article on "Burning Fuel Oil" in the May 23 issue, I think he is doing very well under the present arrangements. He does not give the cost of the oil, but on a basis of B.t.u. he is saving about 22 per cent. by the change.

Assuming that the heating value of his slack coal was 11,000 B.t.u. per pound, or 44,000,000 B.t.u. for the two tons, and allowing 18,200 B.t.u. per pound of oil and 7½ pounds per gallon for the 252 gallons, we have 34,398,000 B.t.u. to do the same work formerly requiring 44,000,000 B.t.u., which represents a saving of about 22 per cent.

Authorities on oil burning all agree that it increases the efficiency of the oil to heat it just prior to firing, and deliver it to the burner under a pressure of from 5 to 10 pounds per square inch, but I doubt if he could do much better by changing his apparatus.

FRED WAGNER.

Chicago, Ill.

Gathering Them In

The editorial in POWER for June 13, "Gathering Them In," suggests many pertinent questions. As an engineer of 25 years' experience I ask the 27 to 29 engineers, how long they have been employed and in what capacity? Do they read any trade paper or talk with other engineers? Do they do the firing, or teach the other man to fire, or let things run themselves? If the management has a steam installation, why not make it profitable?

Is the engineer in charge allowed to spend a dollar of the company's money for improvements? Are his requests treated as worthy of notice? If he is not the right man let the management get another; engineers are not all alike. It may be necessary to pay more, but the new man will have saved enough fuel to more than pay the difference.

Is the matter of power economy discussed with the engineer, and do the coal bills show that he is the right man in the right place? I have in my log book figures which are borne out by the office report of an isolated plant of approximately 2000 horsepower where in corresponding months of 1909 on steam drive and of 1910 on central-station electric drive about $800 was saved by steam drive. The treasurer reported having saved $1000 by steam drive. The company expected to get very cheap power with the electric drive and hoped that by the terms of the contract the saving would pay for the equipment.

After the first few months I never heard anything more about cheap power or of delays in transmission lines. If some of the manufacturers in that "prosperous Massachusetts manufacturing town" want these figures they can get them through POWER.

ALONZO THORNDYKE.

Argyle, Vt.

A Boiler Explosion Averted

Edward T. Binns has a letter in the June 20 issue under the above caption. Now, I do not say that the boiler setting he describes therein is the best that can be devised, but the ones here at my plant are set that way and I cannot see that they have suffered any bad effects. The boilers have been in for about four years and the inspector says that they are in first-class condition. There are also two lap-seam boilers standing out in the yard which have had about 20 years of service in settings of this same kind. They would still be good for duty under a moderate steam pressure.

It is my opinion that those rivets were sheared by some "leatherhead" building a rousing big fire when first starting up.

J. HILTON.

Winfield, Kan.

I was much interested in Mr. Binns' letter in the June 20 issue under the above heading.

I have been in charge of two boilers for the past three years that are set as Mr. Binns described, the hot gases passing over the top of the shell, the object being to superheat the steam. Although these boilers have never shown any signs of defect, I have never felt as well satisfied with them as if the top of the boilers were protected from the gases. These boilers have been inspected by several inspectors and I asked each one for his opinion. They all told me that they did not like that way of setting a boiler but that they did not think there was any danger.

WILLIAM SWOPE.

Tiffin, O.

Writing for the Magazines

For some time past there have appeared in POWER and other mechanical papers numerous articles on how to write for the trade press and why more engineers do not write for publication.

Many feel that their lack of the elementary branches of the English language, their weakness in spelling, the manner of expressing themselves on paper, and perhaps their meager knowledge of mathematics, will disqualify them.

While these failings are drawbacks, they should not bar the way for one who really has something to say that will benefit enough of the readers to warrant its publication.

It has been the good fortune of the writer to travel, particularly in the Eastern and Central States, and he has been brought into contact with men in all branches of the engineering profession from the lowest to the highest, from the ten-dollar-a-week engineer-fireman to men who are in charge of the largest and best plants in the country. These men are often asked, "Do you ever write for publication?" and the great variety of answers would make a very interesting volume.

Here is one reply from a middle-aged man in a plant of perhaps 300 horsepower. He said: "I once wrote an article for a magazine and in about two weeks it was returned with a typewritten letter telling me that as they had so many contributions on hand on the same subjects they were forced to return a number of them. That discouraged me right then and there. I wrote to them on the back of their letter to stop my subscription and keep the change, and I have not taken an engineers' magazine since." This man was easily discouraged.

Another man said: "Yes, I wrote a letter once to a trade journal and in a month or two I got a check for about $5 for my contribution; they said it appeared in a recent number. I hunted through it and finally found my initials at the end of an article that was no more like my copy than day is like night. Those editors slashed it all up, seasoned it with some big words, high-flown expressions and advanced theories, and then sent me the money to pay me to notice the difference. That interested me and I began to learn to spell. My wife taught me evenings. Then I studied grammar from the same teacher. In about a year I wrote again and compared the results, and really found whole sentences just as I wrote them. Then I learned to draw at night school and now when I send in a contribution I can illustrate it as well."

These two answers will illustrate the variety of replies to my question as to why men never write for the press. The principal requirement is that the proposed article is meritorious enough to warrant publication. If so, write your story. Do not put in a superfluous word. Make it concise and yet convey the full meaning intended. After writing it, look it over carefully, correcting the spelling, punctuation, etc. Then rewrite it if it is not neat and legible. Perhaps your employer will permit his stenographer to prepare a typewritten copy for you. Employers appreciate this display of knowledge; they have a high opinion of an

intelligent, ambitious employee, and they receive the benefit of their engineer's studious habits.

While the money which you receive for your contribution is an addition to your salary, do not write for that alone; if you feel that you have got something to say that will benefit some brother engineer, write it and send it to the editors. Leave it to them to determine the amount you will receive for it; they will treat you squarely.

The writer has been benefited many times by the printed experience of a brother engineer and can safely say that there is not a contribution published in any engineers' magazine but that has benefited a number of readers to an equal extent.

Then there is another class of men who ought to write and do not. They are the engineers who are the leaders of the profession, the men who have passed through the elementary grades and have taken a post-graduate course in that great institution, the School of Experience.

Think up your experiences and ask yourself if they will help anybody else. Then get busy.

G. H. WALLACE.

Racine, Wis.

Belting vs. Electric Transmission

In the June 20 issue, there is an answer to my letter in the issue of May 2, by Franklin Van Winkle.

I am sorry that I made the statement about his taking exception to my article in the February 14 issue. I so worded my letter that it would bring a reply, and I always aim to write not only to give such information as I can, but also, if possible, to bring forth arguments for or against such subjects as may instruct me as well as assist others.

The matter of economy in electric drive is very largely the economies to be gained through flexibility of the apparatus. A well laid out mill plant should be and frequently is at the start more economical than a plant electrically driven, but if, because of the conditions of installation in many plants, the drives are not well laid out, the resulting operation is by no means satisfactory. Most every factory is built with the idea of future expansion, as no mill owner purposes to stand still; he always hopes that his business will increase and that the mill will expand. Few owners, however, have sufficient cash or nerve to install shafting and belting with the idea of its being capable of carrying the ultimate expansion that they expect; first, because of the very heavy additional overhead charge which would exist during the time when the mill was small, and, second, because few of them are able to figure in just what direction expansion will take place. The result is that when expansion does take place, the machinery is added and the original belts and shafting have to carry the additional load until the slip and friction and belt wear and belt breakage become very important factors. Slip to a large extent can be overcome by changing the arrangement of the pulleys; but it should be remembered that there frequently are conditions in factory operation which result in light loads upon the plant, and if the belts and pulleys are so proportioned that the belt speed is proper when the factory is running under full load and the machinery under these conditions is running to its maximum productive capacity or safe speed, the machinery will under conditions of light load run at a considerably higher speed and may result in breakage or produce an inferior quality of output.

It is far easier to install a new line of shafting where electric drives are used than where belt drives are employed. A new line under these conditions simply means placing the shaft where it may be desired, without reference to other shafts, and driving direct by a motor, the wiring of which is very simple. If belt drives are used, the shaft must be located with reference to other shafts; and if the load on the new shaft be heavy, it means an entire rearrangement of the belting from this shaft to the main drive or overloading the belts already installed; frequently the arrangement of the shafting is such that it will not allow the best arrangement of the machinery. It is fortunate that the proportion of plants where bad belt drives are installed is not large. If it were, the engineering fraternity and the mill-supply dealers would be driven far beyond their capacity. While the proportion is small, the total number is large, and there is plenty of room for improvement in the manufacturing world along power-transmission lines. It is not always the question of power economy which brings forward electric motors; it is largely a question of economy of space and economy of operation as well as flexibility in its adaptation. A new plant may be installed with power apparatus sufficient for its needs; shafting may be adapted for the machinery at first installed and the original layout kept consistently small. Any further additions to the plant are temporarily taken care of by the overload capacity of the generator; if this is exceeded, a new generator is installed to operate in parallel with the existing one and the plant is operated economically and allows at the same time for both shafting and machinery to be installed and operated in its most economical location. It is unfortunately true, as Mr. Van Winkle states, that the American manufacturers pride themselves on their alertness in adopting improvements inductive to economy, but they do not always follow along the lines on which they operate themselves. They are far more apt to consider that they know what is and what is not economical, not considering that anyone can tell them anything about their business. While it may be perfectly true concerning their main business, it is also a fact that there are lots of people who can assist them in certain parts of their business. These manufacturers are willing to pay a very large sum to a buyer who purchases the raw material for their manufacturing business, paying him a large salary for his knowledge along these matters; but these same people object very strenuously to paying a fair price to a man for his knowledge along power-transmission installation and operation; they depend almost entirely upon their engineer or master mechanic who has probably been brought up in the plant and has been given little or no opportunity to go outside to enlarge his knowledge. It is no reflection upon either the engineer or the master mechanic to say that there are people who could go over the plant and very shortly find places where marked improvement could be made; there are many very excellent men handling plants and installing new machinery in the old-fashioned way simply because that is the way they have always done it.

Still another reason why changes are not made in many power plants is because the power item is as a rule a very small proportion of the total cost in a manufacturing establishment, so small that the saving of half the power would represent but a small percentage in the total yearly cost of operation; and many manufacturers so look at it in this light that they lose sight of what it actually might mean in dollars and cents.

HENRY D. JACKSON.

Boston, Mass.

Friction Load Diagrams

The diagrams taken from an Ames engine and submitted by Mr. Smallwood in the June 20 issue are similar to some that I have seen before. Under light load the engine might be considered as single-acting and working against a steam cushion. If Mr. Smallwood will scrape in the valve and see that the piston is tight for its full travel, I think a different diagram will be produced.

There is a loop in the head-end diagram as well as in the crank-end, the loop in the latter coming much further down. By getting the valve tight this loop will shorten up.

C. R. MCGAHEY.

Baltimore, Md.

It is not altogether what is in the coal but what can be got out of it that makes it valuable.

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POWER

Heat Availible to Steam Boilers —Effect of Moisture in the Air

In a recent issue of *Engineering*, T. B. Morley, B. Sc., of Glasgow University, criticizes the usual treatment of the moisture in the coal in making up the heat balance and computing the efficiency of a boiler.

The boiler is charged with the number of heat units in the dry fuel, but if it has to use a considerable proportion of these to evaporate and superheat to the uptake temperature the moisture in the coal its efficiency, computed as the ratio of the heat units in the steam made inside the boiler to the total number of heat units furnished, will be less than it would were that efficiency computed upon the heat units available for steam making after the fuel had evaporated its own moisture.

So far the criticism appears to be warranted. A boiler is not to blame if it is furnished with wet coal; and it is not enough to reduce the charge to the weight of dry coal and leave the moisture for the boiler to get rid of without credit.

But when he attempts to apply the same reasoning to the moisture in the air with which the furnace is supplied, Mr. Morley seems to have fallen into error. Near the end of his article, which is reproduced upon page 118, he says that in certain boiler experiments recently reported "the moisture carried into the furnace in the air supply amounted to no less than 0.34 of a pound per pound of dry coal; the heat required to convert it into the condition in which it reached the chimney would be about 3.4 per cent. of the heat of the dried fuel."

The moisture in the air might amount to 0.34 of a pound per pound of dry coal. Air at eighty degrees Fahrenheit can carry over two per cent. by weight of moisture, and with quite practicable degrees of humidity and amounts of excess air might carry the quantity in question. But this moisture in the air is in the form of water vapor—steam.

It is already evaporated and will absorb only the heat necessary to raise it from a state of dry saturation at the intake temperature to the superheated condition in which it leaves the furnace.

A pound of dry saturated steam at eighty degrees carries 1094.8 heat units; a pound of steam at fifteen pounds absolute pressure superheated five hundred degrees carries 1385.5 heat units, according to the Marks-Davis tables. Each pound of moisture in the air supplied by combustion would therefore, if it entered at eighty degrees and left at five hundred and eighty degrees, absorb 290.7 B.t.u., and 0.34 of a pound would absorb only about one hundred B.t.u., which is by no means 3.4 per cent. of the heat in the dried fuel. This would be some four hundred or five hundred B.t.u., enough to evaporate 0.34 of a pound of water from eighty and superheat it five hundred degrees. Is it possible that Professor Morley overlooked the fact that the moisture in the air differs from that in the coal as the atmospheric moisture is already vapor and does not need to be evaporated while that in the coal is a liquid?

Effects of Varying the Rate of Steam Supply to a Gas Producer

In the Gas Power Department of this issue will be found a comprehensive abstract of a paper recently read before the British Institution of Mechanical Engineers in which the author describes the results of a series of tests made to determine the effect of varying the ratio of steam to air, or more accurately, steam to coal in a power gas producer. The report is well worth careful and analytical study, notwithstanding the fact that the outfit was too small to justify one in considering the results of the tests as general criteria. The generator was so small, for example, that increasing the steam supply did not produce anything like the increase in carbon dioxide which everyday practice shows. The author, too, is a little dogmatic in some of his deductions; for example: "This result shows that the maximum amount of steam that can be decomposed by anthracite at 1832 degrees Fahrenheit is about 0.535 pound per pound of coal." Such a hard-and-fast conclusion based on tests with a generator ten inches in diameter by twenty-five deep is unsafe, especially in view of the fact that the vaporizer was inadequate to evaporate all of the feed water.

One of the most interesting results of the tests was that the maximum proportion of combustibles was obtained in the gas when the rate of steam decom-

position was about fifty-two per cent. of the rate of coal gasification, but it would have added much to the value of the tests if the investigator had gone into the effect of varying the rate of air supply also. If memory serves reliably, forty per cent. of steam is about as high as American anthracite will take for best results, the rate of air supply being also appropriate. Mr. Allcut lays stress on the fact that the best conditions existed when the water feed rate was about seventy-two per cent. of the coal rate, but as only some seventy-two per cent. of the steam was then decomposed, the steam to coal ratio was really about fifty-two per cent., as already stated.

However, the results obtained by Mr. Allcut are of a great deal of value, when proper allowances are made for the disturbing effects of the small size of the generator employed. We should like very much to see such a painstaking series of tests carried out in this country on a producer of, say, two or three hundred horsepower.

As this editorial is being written, we find that the tabulated results of Mr. Allcut's tests were accidentally omitted. This table will be printed next week.

Safety Stops

The safety cams on a Corliss engine valve gear are put on to prevent an accident due to the engine taking steam at full stroke, should the governor from any cause descend to its lowest position, just as a safety valve is placed on a steam boiler to prevent an accident if the steam pressure should tend to rise above a safe point.

There is one radical difference, however, between these two safety devices: while the safety valve may be set for the desired pressure and not be tampered with further, except to see that it is free to operate, it is necessary to block the governor in an unsafe position every time the engine is shut down, so that it may be started again.

Engine builders have provided stops of various kinds for this purpose, many styles requiring that the engineer place them in the safety position after the engine has attained sufficient speed to raise the weight of the governor from the stop. There is no excuse for using a stop of this character as there are numerous simple means by which this action may be made automatic; many of them have been described in our columns from time to time.

An engineer is very negligent if he continues to operate an engine with a stop that is not automatic; and he is criminally negligent if, as is often the case, he so purposely changes an automatic device of this character that it is rendered inoperative. Should an accident occur under such conditions due to the misplacement of the stop he should be treated the same as any other criminal.

Why should a nonautomatic stop on a steam engine be tolerated any more than a stop valve between a boiler and its safety valve? Flywheel explosions are of alarming frequency, and the records of a company doing both flywheel and boiler insurance tend to show that the hazard connected with flywheel insurance is far greater than in boiler insurance, a flywheel apparently being 30 per cent. more liable to explode than a boiler. The point to be first considered in power-plant operation is safety, and it behooves the intelligent engineer to remove without delay such a simple cause of flywheel accidents as a nonautomatic safety stop.

The Importance of Brains

Some men are prone to be so dully perceptive of the exceeding earnestness of life, of the right uses of their mental faculties, that it is quite possible the forceful if somewhat vulgar expression, "He's a dead one," had its origin in this observation. Carlyle wrote some seventy years ago, "It is a most earnest thing to be alive in this world."

Mental development plus energetic labor makes for commercial and industrial success and keeps the wheels revolving. An observant man on entering a big power plant of the present day is profoundly impressed with the evidences of mechanical genius that are to be seen everywhere about him; the plant fairly bristles with brain products.

With the necessity for machines of immense capacity has come the demand for the highly skilled workman, the mechanic who works with his brains. The plant owner who told the maker that he wanted "machines so simple that any fool could operate them" failed to realize that this particular fool and his machine are soon parted, to paraphrase the old saying.

The enormous sums of money annually invested in power plants in the United States alone would yield little if any return were the owners not keen to the necessity for employing skilled labor.

So large is the skepticism of a few individuals that under ordinary conditions they only believe in those things which they see with their own eyes. As they have never seen their brains we may be pardoned for appropriating their own line of argument: Their brains have no existence in fact. It is this type of man who "ain't got no use for book learnin' and them theory fellers," and they make about as big a showing among their fellows as does a pimple on a fat man's nose.

The bright, common-sense mechanic is rapidly beginning to know that to develop a thorough working knowledge of his vocation, the theory as well as the practice is required if he expects to go to the top. He sees the importance of brains and will set them to work at once; that it is not sufficient to know what is good practice but why—and the *why* is the theory.

To be sure, theory must be kept within bounds; theory and "theorizin'," as Mulvaney called it, are widely apart. Occasionally an enthusiastic young college graduate may think that he can instruct the best operating engineer who ever ran an engine and detect faulty design in an almost perfect machine. Of course, he is "all down but nine," as the bowlers phrase it. But when this young hopeful has overcome his reluctance to the overalls and the shop—has come within bounds—his brains tell him he is but poorly equipped as an engineer until his apprenticeship has been served under the eye of the skilled, intelligent mechanic and he has acquired the highly necessary practice.

Government Research Work

While the newspapers have been printing glaring headlines on "conservation" and certain individuals have been stumping the country preaching "efficiency," the Government has been quietly conducting scientific investigations which are destined to have a far more permanent effect upon engineering economy.

This refers to the experimental work upon fuel, combustion, feed water, etc., which was formerly carried out under the supervision of the Geological Survey but has now been transferred to a separate department, the Bureau of Mines. Under the direction of this bureau the scope of the work has been extended and excellent results have been attained, as will be noted from the report to be found elsewhere in this issue.

The majority of small plants and industrial establishments have neither the money nor the facilities for conducting research work, and many of the larger plants that have consider the results as "company data." Moreover, commercial tests, however accurate, are always looked upon as more or less biased; consequently their value as general engineering information is often unjustly discounted.

The work of the Bureau of Mines, however, is known to be strictly impartial; it is carried on by a corps of trained experts and the results are at the disposal of those sufficiently interested to send for the bulletins. For these reasons this department of the Government should receive the hearty support of all those engaged in power-plant engineering.

Engineers are finding out that the air space in the brick setting of boilers is not such a help in preventing heat radiation as has been generally believed for years past.

Engineers who possess the most information seldom use it in belittling the man less fortunate.

Inquiries of General Interest

Questions are not answered unless accompanied by the name and address of the inquirer. This page is for you when stuck—use it

Object of Flue Gas Analyses

What is the object of flue-gas analyses, and what does the presence of carbon monoxide (CO) in the flue gas indicate?

O. F. A.

Flue-gas analyses are made for the purpose of determining the conditions of combustion obtaining at the time the gas is made. The CO indicates a lack of air. If the combustion is perfect, all of the carbon will be burned to CO_2, but if not enough air is used, part of it burns to CO and gives up only about one-third of the heat that comes from burning it to CO_2.

Air in Pump Suction Pipe

We had a 4x2½x4-inch pump installed to pump water from a couple of wells. The first suction pipe was 1 inch and the pump ran all right, but did not give enough water. The 1-inch pipe was taken out and replaced with a 1¼-inch. The pump would not then deliver as much water as it did before. A 6x4x6-inch duplex pump was then tried. It handled the water but would not run faster than a certain speed, owing to the friction in the suction pipe. What is wrong?

S. C. A.

From the behavior of the small pump it would seem that there are air leaks in the suction pipe, which, though not large enough to affect the larger pump noticeably, still admit air enough to seriously interfere with the operation of the smaller one. You can, of course, see that at the same rate of piston speed the duplex pump will take care of about five times as much water as the single one, and consequently a correspondingly larger volume of air.

Designing Bumped Head

How do you find the radius and the thickness of a bumped head?

O. W.

The radius to which a head should be bumped is determined by the formula

$$R = \frac{S \times T}{F \times P}$$

in which

R = One-half the radius to which the head is bumped;
F = Factor of safety;
P = Working pressure;
S = Tensile strength of material;
T = Thickness of the head.

To find the thickness, transpose the formula to

$$\frac{R \times F \times P}{S} = T$$

Collapsing Strength of Cone

A cone-shaped flue has a greatest diameter of 36 inches, a least diameter of 12 inches and a length of 20 inches. It is built of 5/16-inch steel plate of a tensile strength of 60,000 pounds per square inch. What collapsing pressure will such a flue safely withstand?

W. P. C.

It is customary in short cones to take the mean diameter, in this case

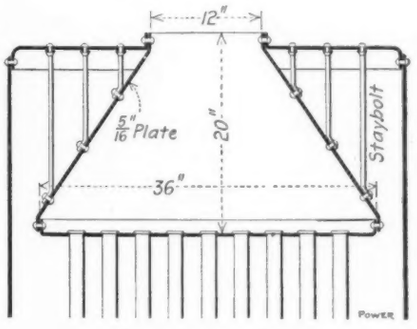
$$\frac{36 + 12}{2} = 24 \text{ inches}$$

and calculate the collapsing strength. Hutton's rule is

$$\frac{T^2 \times C}{D \times \sqrt{L}} = P$$

where,

T = Thickness of plate in thirty-seconds of an inch;



CONE-SHAPED FLUE

D = External diameter of shell in inches;
L = Length of shell in inches;
C = 660 for mild-steel plates, and
P = Collapsing pressure.

Substituting,

$$\frac{10 \times 10 \times 660}{24 \times \sqrt{20}} = 614.9 \text{ pounds}$$

The collapsing pressure must be divided by the factor of safety and in view of the high temperatures and wear and tear this should be 6. The allowable pressure would then be 102.5 pounds per square inch. The cone must be truly circular in form.

The bracing for the flue should be placed as shown in the accompanying sketch in order to prevent the flue from being pushed down by the pressure exerted on its inclined surface.

Engine Steam and Exhaust Pipes

How is the size of steam and exhaust pipes for engines determined?

S. E. P.

The steam pipes should be so proportioned that the mean velocity will not exceed 6000 to 8000 feet per minute, and that in the exhaust pipe around 4000. A considerable diversity of practice exists and it is largely a question of how much drop in pressure one is willing to stand.

Open and Closed Feed Water Heaters

What are three advantages of an open feed-water heater over one of the closed type?

O. C. H.

An open feed-water heater saves the condensed steam which brings the heat to it; it saves the heat which would otherwise go out in the water of condensation and as usually arranged with a settling chamber and filter it takes out the impurities which are deposited at the temperature to which the water is raised.

Water Tube and Return Tubular Boilers

What are three advantages of water-tube boilers over return-tubular?

W. R. T.

A water-tube boiler is not so liable to disastrous explosion as a shell boiler. It is adapted to the carrying of higher pressures than externally fired shell boilers can carry in any considerable sizes, and it gets a larger capacity into the same space.

Suction Chamber

What is the object of the chamber on the suction line of a pump?

P. S. C.

The object of an air chamber on the suction line of a pump is to take up the impact of the moving column of water and to give a more uniform flow to the pump cylinder.

Heating and Ventilation

Considered as power plant problems. Layout and operation of systems and apparatus

Hot Water Heating by Forced Circulation*

By Ira N. Evans†

It has always been conceded that hot-water heating is the most economical and satisfactory method because of the flexibility of the medium in its wide range of temperature to meet changes in outside weather conditions.

It is understood that the circulation of a gravity hot-water heating system is induced by the boiler or heater warming a column of water in one part of the system whose lighter weight is balanced against a column of colder water in another part, causing a flow to regain its equilibrium. The circulation is therefore dependent on the hight of the apparatus and a difference in temperature of the circulated medium in different parts of the system or there is no movement.

The low temperatures and slow circulation of the gravity systems due to the slight difference in weights of the cold and hot columns require mains and radiators of sizes so large and so expensive as to be prohibitive on a job of any magnitude.

To overcome these objections forced circulation was employed by introducing into the hot-water circuit a mechanically operated pump.

In proportion to the amount of power applied to the pump to circulate the water the temperature of the medium becomes independent of the power of circulation. A reduction in the size of mains occurs as well as an increased efficiency in radiators, boilers and heaters to transmit heat units from steam, water or hot gases. Grades can be disregarded and the only limit to the distance is the first cost of the pipe lines when compared with that of another plant.

Where steam power was available for power purposes hot-water boilers were replaced by heaters to warm the circulated water by either exhaust or live steam from the power boilers.

The above described arrangement is known as the system of hot-water heating by forced circulation and is applicable to large central heating plants where the distances transversed are long and it is desirable to use waste heat from any source.

Hot-water heating by forced circulation has been on the market in various forms for about 18 years, but the majority of owners and engineers have but slight conception of its possibilities as there is a dearth of literature on the subject.

All systems of hot-water forced circulation require a pump in the circuit but differ in the forms of heaters and their connections and methods of handling the steam and condensation.

The inventor of the first system stumbled on the idea during his practice while engaged in heating a greenhouse on a level considerably below that of the boiler house where a gravity system was out of the question. For many years noncondensing engines only were used to supply the exhaust steam to heat the water, thus positively doing away with back pressure by omitting the back-pressure valve from the exhaust pipe. The next step was the development of this system in connection with turbine and condensing engines.

The type of heating surface, whether direct or indirect, is practically the same as for steam systems, only instead of a larger supply pipe and small return there are two pipes of the same size dependent on the quantity and velocity of the water required to be circulated.

In the first installation the pumping capacity was comparatively small in proportion to the heating surface and this is the error most engineers make in their first installation. A few of the special schemes of heating by this method are described, and all of them include the continuous circulation of the same water and heaters of the closed type with no connection between the steam and water spaces, the heat units being transmitted through the tubes and surfaces.

One system has a hot-water heating boiler in the circuit through which the water is circulated which absorbs heat from the fire under the boiler. A low-pressure tubular heater may be included to utilize the exhaust steam from the engines. The boiler is operated when the exhaust steam is insufficient. This requires the installation of hot-water boilers in addition to the steam-power boilers in the same plant, which are idle in summer.

It is very difficult to regulate the fire under hot-water boilers on account of the wide variation in heat requirements due to outside weather conditions. More boilers are needed in extremely cold weather and when it suddenly moderates the fires have to be banked. This makes the plant difficult to control as regards the temperature of the water.

Several town heating plants were installed in the West using the hot-water forced-circulation system. Hot-water boilers were installed to heat the circulated water and in some cases the live steam for heating was supplied to a heater from power steam boilers. The special feature of this system lay in the method of utilizing and storing the heat of the exhaust steam.

An exhaust heater was installed and the exhaust steam from the engines was condensed by storage water circulated to a large tank in series with the heaters and pumps. The use of a tank or reservoir of water of sufficient capacity to store the heat at periods of heavy engine load was necessary and was used during periods of lighter load.

A piston-type pump circulated the water which was forced to the highest point of the system and allowed to flow back by gravity through a small return opening controlled by a valve. In this manner the pump had to work against the greatest static head of the system as well as the friction head due to the piping. This method also required an excessive drop in water temperature. It was also found that no isolated tank or reservoir of practical size would hold sufficient water to allow an appreciable amount of heat storage, thus causing the abandonment of this feature. A common arrangement is the use of one large heater having an exhaust connection with a back-pressure valve and a live-steam connection through a reducing valve, a pump and receiver handling the condensation, the pump for the circulation of water through the mains and radiators remaining as usual.

This arrangement has flexibility and the circulation is independent of the temperature of the circulating medium, but many features in the handling of the condensation are lost by this method. The pump and receiver reducing valve and the back-pressure valve involve most of the difficulties of the vacuum steam system.

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†Consulting engineer, heating and power, New York City.

Another arrangement advocated by a large firm is the placing of the live-steam heater and exhaust-steam heater in parallel as regards the water connection, but this has the effect of reducing the capacity of the heating surface in the heaters if used together as only one-half of the water in the system flows through each heater. If this connection were full size and the heaters were not used at the same time, it would not make an appreciable difference provided the water connection to the heater not in use were closed. The high-temperature steam available in the live-steam heater over the temperature of the exhaust in the other makes the advantage of the series connections apparent.

There is a system of town heating operated in Ohio which utilizes a cooling tower in connection with the heating system to act as a condenser.

The exhaust heater and the surface condenser are combined, the water passing through the condenser to the heating system and thence back to the cooling tower. The vacuum corresponds closely to the temperature required for the heating water in the flow main. In this system the pipes would be subject to pitting on account of the new water introduced to replace that lost by vapor from the cooling tower, and necessitates pumping against the total hight or static head of the system unless the cooling tower can be made the highest point of the system.

The best practice is shown for water and steam connections for operating under condensing conditions in the accompanying illustration. The live-steam heater is placed over the boilers as high as conditions will permit to obtain a gravity return for the all-live steam used on the system. The condensation returns to the rear drum of the boiler by gravity at nearly the same pressure and temperature as the water in the boilers.

When the condensation of the steam is so heavy that the pressure in the heater is reduced below that of the boiler to an extent greater than the column of return water between the level of the water in the heater and the water line of the boilers, the operation is as follows: An injector tee *J* and separate 1-inch steam line *I* from the boilers inject the water back into the boilers and overcome the difference in pressure between the heater and boiler. This injector will generally be required if there is less than 10 feet between the water line of the boilers and the bottom of the heater; under conditions of extreme service it should be shut off.

When only a portion of the heater capacity is required the steam valve to the heater is throttled to the point desired and the condensation covers the tubes, thus reducing the amount of exposed heating surface automatically without interfering with the equal expansion of the tubes and the shell.

When the throttle valve on the heater is wide open and a further capacity is desired, the injector tee is employed. The fact that the bottom of the heater is full of water at a less temperature and pressure than the boiler makes the conditions favorable for the action of the injector. It should not be unnecessarily used; warning is given by a slight snapping in the return pipe which shows that it is emptying.

When a pump and receiver are used with a live-steam heater the latent heat units in the exhaust of the pump nearly equal or exceed those in the returned water, and, as a rule, a vapor pipe is provided on the receiver and a drain trap is placed between the receiver and the heater. Part of the discharge from the trap will reëvaporate because the pressure is lowered and is lost through the vapor pipe. The difficulties with pumps handling high-temperature condensation are well known.

In practice there is nearly the same loss and effect in passing steam through a reducing valve due to wiredrawing condensation, etc., as passing the steam through a steam engine, notwithstanding the superheating effect. For the above reasons when live steam is handled direct to the boiler by the injector method there is a saving of about 10 to 15 per cent. on the amount used and the difficulties in the proper connection of a return trap are avoided.

The live-steam heater should have a capacity sufficient to heat the water for the entire plant under maximum conditions without the exhaust heater. Its size should be determined under a steam pressure of about 100 pounds. The power boilers may operate normally under a higher pressure, but as the heater is used in industrial plants when the engines are inoperative it is advantageous and generally customary to lower the boiler pressure to about 100 pounds at that period. This does not increase the size of the heater materially and gives greater capacity.

The exhaust heater is connected in series by the water pipes with the pumps and live-steam heater with bypasses and valves as shown.

When operating on a condensing plant the connection between the engine or turbine and the condenser are made as indicated; the amount of vacuum on the heater regulates the water temperature and is controlled by opening or closing the valve *X*. There may be full vacuum on the condenser with other units exhausting into it. The dry-air pumps and condenser circulating pumps are not shown.

The hotwell pumps handle the condensation from the condenser and heater and are cross-connected. They discharge to the open feed-water heater. If the heater can be placed above the condenser the same hotwell pump could handle the condensation from both.

The remainder of the valves about the heater are for shutting it out when operating under full vacuum. This change is made with this arrangement without stopping the main machine.

It is impossible to get perfect opera-

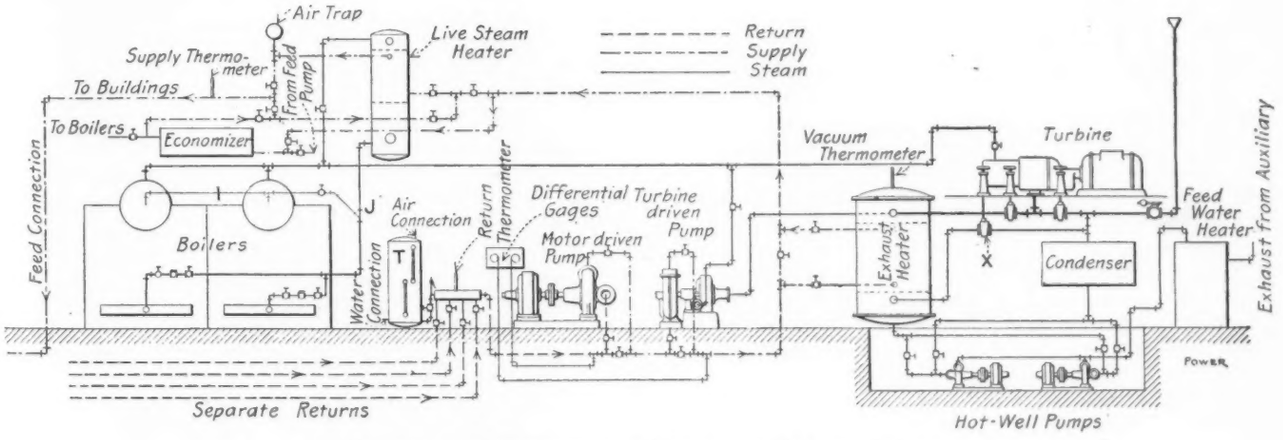


DIAGRAM OF CONNECTIONS OF HOT-WATER HEATING SYSTEM

tion under all conditions by combining the heater and condenser in one machine. The power determines the amount of steam furnished and the rate is fixed by the amount of vacuum desired to heat the hot water for any given condition of outside weather.

When the engines are operated noncondensing the steam connection to the exhaust heater leads to the atmosphere in the usual manner without a back-pressure valve. The only reason for using a back-pressure valve occurs when the exhaust heater is too small and it is desirous to raise the pressure and temperature of the steam above the atmosphere. It is a mistake to apply a trap or other apparatus than a pump to the exhaust heater when operating under vacuum unless there is sufficient fall for the return pipe.

When the live- and exhaust-steam heaters are connected so that the condensation of both is handled by a pump and receiver the live-steam heater might be omitted and a reducing-valve and back-pressure valve connection be made to the exhaust heater.

It will therefore be seen that with the two heaters as described all the operating advantages of both a high-pressure steam system and a low-pressure vacuum system are obtained without their disadvantages outside of the initial cost of heaters and pumps.

When the exhaust steam is below what is necessary in very cold weather and sufficient for average weather in the case of a noncondensing plant it is sometimes economical to install a live-steam heater with a drain trap, flashing the condensation into the steam space of the exhaust heater, with a pump to remove the condensation at low temperature from the exhaust heater. During periods of moderate weather when the live-steam heater is not required, a vacuum nearly corresponding to the outboard temperature of the heating water may be carried.

The pumping apparatus, shown in the figures, may be either motor driven or steam-turbine driven. When the exhaust of the main turbine is sufficient it is good practice to use one motor pump and one steam-driven pump when the main engine is shut down. These pumps should be of the turbine type with hollow bronze followers and of proper head and capacity.

The connections should be made in series as shown and each pump should be of ample capacity to handle the entire plant. As it is only the expense of one or two valves it is best to so connect them in series that both can be run at a time if desired. This is especially advantageous where the exhaust of a large turbine is used under partial vacuum in extreme weather. The average water temperature is reduced 5 or 10 degrees, which counts heavily on the vacuum when near atmosphere. There is nothing gained by connecting the two pumps having the same head and volume in parallel as with the frictional resistance of the piping constant for a given velocity and varying as the square of the velocity, the only way the discharge can be increased is by placing the pumps together in series and increasing the head.

Piston pumps have been discarded as they are not applicable to low heads and large volumes, and with the head balanced on the discharge and suction the valves make a racket that is heard throughout the piping system.

Motors to be operated on centrifugal pumps should be carefully designed for speed and power; when direct connected to a pump any increase in speed rapidly increases the consumption of power and endangers the overload of the motor. The pump operates on very high speed for efficiency and where direct-current motors are used special commutators should be employed so that the commutator speed will be low enough not to spark and still take care of the necessary current.

The apparatus should be full of water and free of air and a pressure of 15 pounds above the static head is advantageous. It is bad practice to pump against the static head of the system and can easily be avoided. The pumps should only operate against the friction head of the piping.

The best practice is to circulate the water as rapidly as possible at all times, reducing the drop in temperature between the plant and the radiators and thus lowering the average temperature of the water.

Change the temperature of the heating medium by varying the amount of steam introduced into the heaters or vary the vacuum in the case of a condensing plant rather than the speed of the pumps and the rapidity of the circulation. Rapid circulation also increases the transmission of the surfaces in both the heaters and the radiators and thereby increases their efficiency.

It has been found by actual experiment that about 80 per cent. of the mechanical energy of the pump reappears in heat which is absorbed by the circulated water and therefore slightly raises its temperature. The friction and consequent heat are caused by the rapid movement of the water against the sides of the pipe.

As the exhaust steam from the prime mover of the pump is also used in the heater it will be seen that ample circulating power is not so expensive as at first considered.

There have been quite a number of systems installed which use the heat from annealing ovens and economizers with hot-water circulation. I know of one case where 200 horsepower in heat units was obtained from the hot gases of a brass furnace, a heater being connected in the circuit of an existing hot-water system. The high cost of economizers makes their use on the hot- water heating system questionable, especially as the high temperature of the gases makes them available for feed-water purposes under all conditions, whereas the heating plant does not operate in summer. The amount any economizer will do is dependent on the quantity of coal burned at any time under the boilers, regardless of their size and the limit in temperature of the gases that will not interfere with the draft. Where an economizer is installed for feed purposes and the power is inoperative at night it pays to cross-connect it on the heating system and it will absorb about 15 per cent. of the heat of the coal burned at that time. It usually does not pay to install an economizer solely for heating purposes due to the possible high temperature available for feed water. However, due to the larger volume of water passed through it when operated for heating, the transmission is high.

In planning the installation of a hot-water heating system, especially in connection with turbines or condensing engines, the type and size of the engine and the arrangement of the plant should be modified to suit the hot-water system to get the best results. This is seldom done as the types and sizes of engines and boilers are generally determined upon long in advance.

With the arrangement of gages and thermometers in the form of recording instruments a complete daily record can be kept of the output of the heating system in the same manner as is the electric current. This is an important feature in keeping track of the leaks in output in an industrial plant and cannot be accomplished as easily as in steam-heating systems; very few owners know what it costs to heat their buildings. If they have exhaust steam they generally say it costs nothing, while with a system as described above they could operate condensing nearly the year around.

Alaska's Coal Unlimited

In coal resources Alaska stands supreme along the entire Pacific coast. There is, indeed, plenty of coal in the State of Washington, and Vancouver island has probably more coal under it than ever had England, but for a high-class anthracite or bituminous coal the present and future generations of the Pacific coast must turn to Alaska, as that is the only place it exists. The high-grade, smokeless coal so essential for the Pacific squadron of our Navy exists only in Alaska. The future of the Pacific coast maritime interests, as well as high-class manufacturing industries, is largely dependent upon Alaska for fuel and for tonnage for the ships.—*The Coal Trade Bulletin.*

Chicago Meeting of the Heating and Ventilating Engineers

At the regular summer meeting of the American Society of Heating and Ventilating Engineers, held at the La Salle hotel, Chicago, July 6 to 8, a number of papers bearing on subjects of interest were presented.

Paul P. Bird, of Chicago, read a paper entitled "Some Phases of Smoke Prevention." In the last 60 years the amount of coal used for power and heating in the United States has grown to 480,000,000 tons annually, about 80 per cent. of which is bituminous. It can readily be imagined that the smoke nuisance brought about by this extensive use of coal is a factor of great importance in our modern civilization.

Comparing Chicago, plant by plant, stack by stack, with other cities, it was claimed to be the cleanest of any of the large municipalities where bituminous coal is used. An outline was also given of the smoke department of the city and of the duties which it has to perform. Owing to the power given the department in supervising new installations and the rearrangement of old plants, within 15 years all steam plants in the city will come under its supervision and a material abatement of the smoke nuisance will be made.

Three important items must be considered with relation to the smoke problem in Chicago: First, the kind of coal; Illinois and Indiana coal must be the principal fuels used in this district, therefore the department has no control over this phase of the subject.

Second, the care of the firemen. This is a matter coming only indirectly under the department's supervision as the men are employees of the steam-plant owners, although coöperation is bringing good results.

Third, the equipment. Over this item the city has direct control and a great deal has been accomplished.

Draft is by far the most important item of the smoke problem. The shortest chimney allowed for small plants in Chicago is 100 feet high, while in the largest plants the hight is 250 feet. Records show that during the last administration the smoke nuisance had been reduced 30 per cent. Practical means for further reducing the nuisance were listed as electrifying of railways, the use of central stations, boats using oil fuel and coke, and the use of gas and coke for heating in residences.

Mr. Bird also drew attention to the large field for the heating and ventilating engineer in designing heating plants for preventing smoke and said that the problem was worthy of the most careful thought and study.

Other papers presented at the meeting, some of which will be abstracted in these columns, were "New Basis for Rating House Heating, Boilers and Furnaces," by Frank L. Busey; "Heating and Ventilating High School Buildings in Decatur, Ill.," by Samuel R. Lewis; "Ventilation of the Macy Store in New York," by D. M. Quay; "Notes on Tests of Warm Air Furnace Pipes," by A. W. Glessner; "Street-car Ventilation," by W. Thorn.

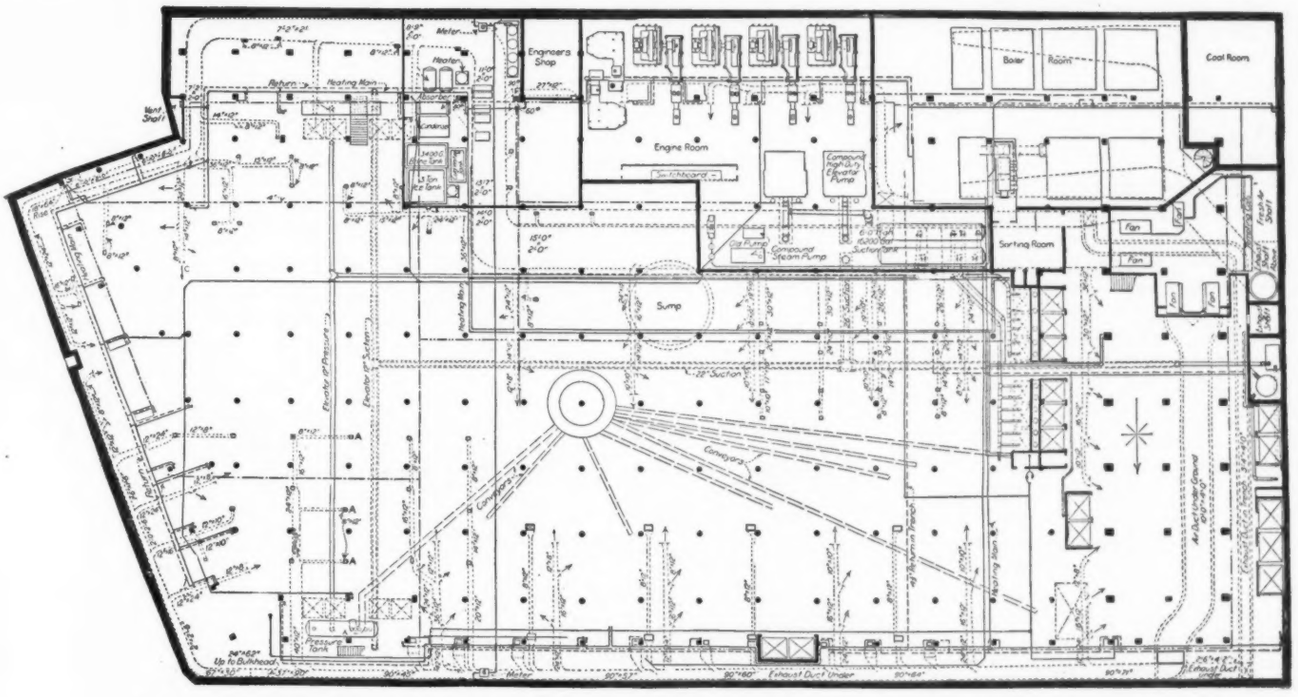
In addition to the usual automobile rides and excursions to points of interest in the city, there were a moonlight excursion on the lake, Friday evening, and a dinner with special musical features at the La Salle hotel roof garden.

The next regular meeting of the society will be held at the Engineering Societies building, 29 West Thirty-ninth street, New York.

Ventilation of the Macy Store, New York*

By D. M. Quay

The object of this paper is to describe briefly the ventilating arrangements, particularly of the underground portions, of the department store of R. H. Macy &



Plan of Subbasement of Macy Department Store, Showing Heating and Ventilating Apparatus

Co., at Thirty-fourth street and Broadway, New York City.

Like the average department store, there is a basement below the ground floor given over to retailing, this level being low enough so that windows and the free circulation of outside air are inadmissible, and below this there is a subbasement devoted partly to the mechanical plant of the building and partly to the shipping and delivery departments. In the present case not only are the basement and subbasement supplied with pure air delivered positively by mechanical means but an air supply is given to the main floor.

The accompanying plan drawing of the subbasement will assist in showing

*Abstract of a paper read before the American Society of Heating and Ventilating Engineers, Chicago, July 6 to 8.

the scheme of ventilation. The building has three street sides and the fourth wall accommodates some of the elevators and the large fresh-air and exhaust flues. The air is taken from a point above the roof level and is carried down a 12x24-foot shaft. At the subbasement the air may be passed through underground passages with tempering coils bypassed at will in the usual way and then reaches two pairs of 160-inch steel-plate blowers, four in all, which discharge the air through ducts for the supply of the subbasement, including the engine and machinery rooms and the basement and the first or main floor.

There are two main fresh-air discharge ducts, one from each pair of blowers, the first supplying the north side of the building and carried under the basement floor; the other is along the subbasement ceiling along the boiler, engine and machinery walls to the east end where it is carried around parallel to the south wall. Finally both are extended to the ceiling of the basement to supply air delivered for reheating coils at the main entrances, of which there are three, one at the northeast corner, one in the east center and one at the southeast corner. The supply of air under the slight pressure serves to prevent an inrush of cold air with the opening of the doors.

The various fresh-air branch ducts from the main ducts supply the subbasement and the first story, with reheating coils in connection with each branch duct, except those for the engine, boiler and other rooms of the mechanical plant which develop more heat than is necessary for warming purposes. The tempering coils and reheaters are regulated by the Johnson system of automatic control. The automatic control of reheaters regulates the temperature as desired in different parts of the store, each such reheater being under the control of a separate thermostat.

The basement and first story are most crowded toward the central portion, and with this point in mind the system was designed in connection with these floors to deliver the air to the central parts instead of to points along the outside walls. This was done by placing grills on the fronts of the counters carrying the branch ducts on the ceiling below, alongside the deep girders, to outlets in the counter fronts. The air risers are marked *A* on the subbasement plan. In the stove and household-goods department in the basement, however, large registers were placed in the floor in an out-of-the-way place, as there are no permanent counters in this section of the store.

A mechanical exhausting system is also provided which removes the vitiated air from the boiler, engine and machinery rooms, from the shipping and delivery departments, from the toilet and locker rooms and from the kitchen, laundry, bakery, etc., on the eighth floor. No air is blown into the toilet rooms in except one large room in the basement, where about two-thirds as much air is blown in as is drawn from the room, so that there is always a slight suction in all the toilet rooms to prevent an uncontrolled escape from such rooms to other parts of the building.

For handling the exhaust air there are two 10x10-foot air shafts at the rear wall and the space around the chimney is also used to assist in the exhaust system. These are fitted with fans and there is also a 12-foot exhaust fan located near the ceiling of the engine room. This draws air from the engine and machinery room and discharges it through a 12x12-foot grating to the outside atmosphere. A 120-inch steel-plate exhauster at the rear of the boiler room draws air from the boiler and pump rooms and discharges it into one of the exhaust shafts.

An interesting detail was developed in connection with the power required for driving the fresh-air blowers. So great was the chimney effect of the lofty downtake shaft tnrough which the air had to be brought from above the roof that motors were installed of about 25 per cent. greater horsepower than would normally suffice.

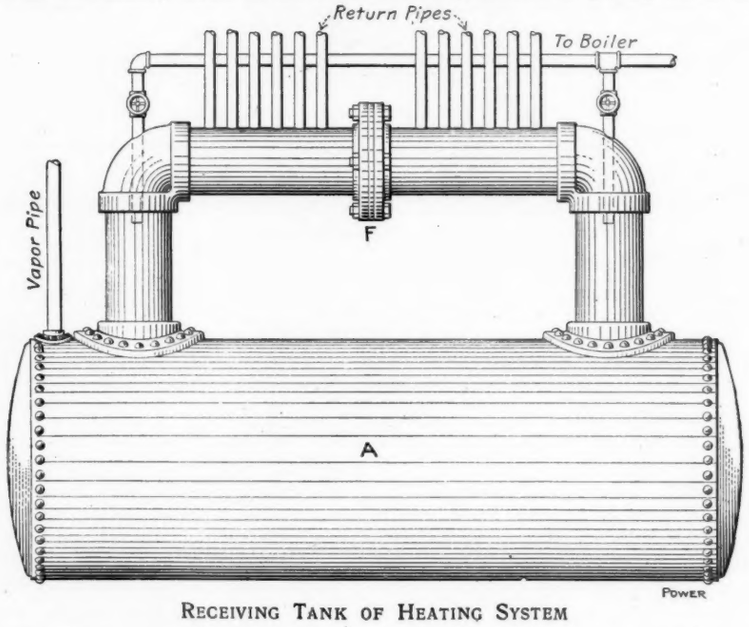
A recent test made by the chief engineer of the building with thermometers placed at different points on the eighth floor, a large open space with numerous windows, and also in the shipping department of the subbasement, showed less than 2 degrees difference in temperature on the two floors. It was his opinion that the air in the subbasement was as pure as the outside air, and that it was in constant motion in all parts of the floor. There is no complaint of drafts.

The foregoing, of course, deals only with the operation of the heating and ventilating plant. The building is heated by direct radiation, of which there are 62,000 square feet, and incloses no less than 16,000,000 cubic feet of space. There are 7000 square feet of tempering-coil surface and indireet radiation in reheaters. The boiler plant is of 3020 horsepower and in the mechanical plant there are four 500-horsepower and two 300-horsepower electric-lighting units, 32 hydraulic elevators; and a 25-ton refrigerating and water-cooling system forms part of the plant. Some of the other apparatus making a power demand on the plant are four moving stairways, the parcel delivery and conveyer systems mentioned and a vacuum-cleaning system. The plant also includes a garbage and refuse destructor.

LETTERS

Improving Circulation through Heating Coils

In a large manufacturing establishment heated by exhaust steam, trouble was experienced in getting steam to circulate through the coils on the top floor, especially after starting up in the morning.



RECEIVING TANK OF HEATING SYSTEM

It would take an hour or more for the coils to become warm. The engineer hit on a scheme which did the trick in five minutes or less. All returns went to a 4-inch header on a receiving tank, as shown in the sketch. The flange *F* was blanketed. The two ells were tapped for ½-inch pipes which were inserted, as shown by the dotted lines, in the pipes leading to the tank *A* from which the feed water was taken.

These ½-inch pipes were connected to a live-steam pipe leading from the boilers. After starting up in the morning the engineer would open the two ½-inch valves above the ells and turn the live steam into the receiving tank. This formed a partial vacuum in the return

pipes and in a few minutes all the coils would be warm. The engineer would then close the valves and thus shut off the live steam for the rest of the day.

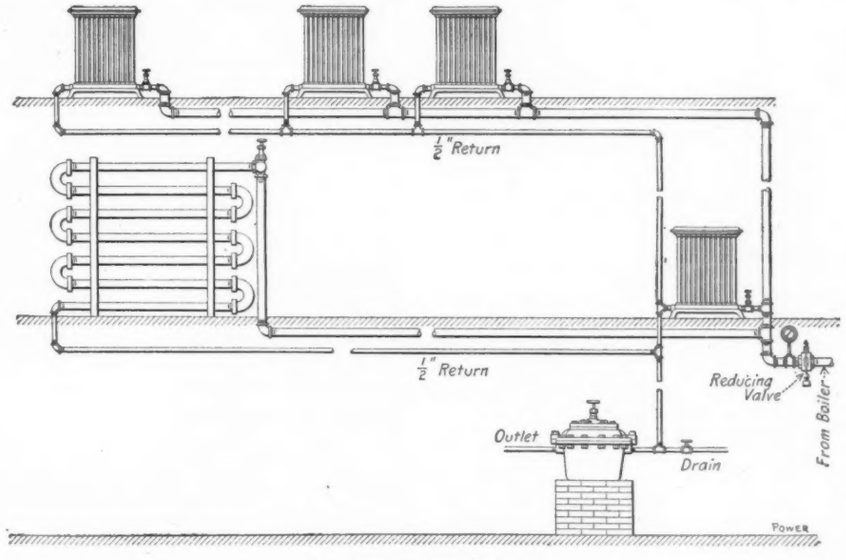
A. RATHMAN.

Chicago, Ill.

Radiators Give Trouble

The pipe dimensions given in the sketch submitted by B. E. Thomas in the June 13 issue of POWER to illustrate the layout of his heating system, makes it clearly apparent why the three radiators on the second floor fill with water. The return piping is shown as ½ inch throughout, whereas this size of pipe is altogether inadequate for any part of a return system operating without vacuum, as in the present case.

From its relative size it may be presumed that the heating coil on the first floor furnishes a very considerable portion of the total condensation occurring



RADIATORS AND PIPING

in the system. Also, it would seem that on account of its close proximity to the source of supply, the first-floor radiator receives its steam under a pressure somewhat in excess of that in the horizontal length of pipe which supplies the upper radiators. These circumstances obviously combine to choke back the flow of water through the quite insufficient ½-inch vertical return pipe.

With respect to the remedy, it would seem that if the heaters on the first floor received their supply of steam from the overhead horizontal line, a much nearer approach to equality of pressure at the various controlling valves of the system would be realized, thus doing away with the retarding influence upon the flow of water from the upper-floor radiators which the superior steam pressure prevailing in the lower radiator, as originally connected, would naturally exert.

In the matter of the return piping, the branch leading directly from each member of the system should be of ¾-inch pipe. Hence, the size of the horizontal length to which the return branches from the three upper radiators connect, should increase from ¾ inch in the section most remote from the trap to 1 inch in the middle section, and 1¼ inches thence to the vertical drop, which likewise should be of 1¼-inch pipe.

A means for drawing the supply riser should also be provided.

A. J. DIXON.

Chicago, Ill.

The system indicated by the sketch is what is known as a "dry return" and according to the diagram, Mr. Thomas, after carrying his steam 80 feet from the boiler, makes no provision for bleeding the line. I would suggest that he bleed the riser just after leaving the reducing valve and connect to the trap. Then I should make sure that the trap is large enough to take care of the condensation and that it is in proper working order. When sure of these things, I should, if the system still failed to work, put a check valve in the return line above the connection to the first-floor radiator, preferably in the horizontal run.

W. A. COX.

Albany, N. Y.

Before being able to suggest a sure remedy, several points ought to be known, viz.: How large are the radiators? To what pressure is the steam reduced? Is the trap low or high pressure? Does the trap exhaust against a back pressure or to the atmosphere? What capacity has the trap?

The sketch shows four radiators and a pipe coil, all taking steam from a 1-inch steam pipe. Assume these radiators to be of the standard four-pipe type, 3 feet high, and from the sketch 10 sections long. Each section would contain about 8 square feet of surface, or approximately 80 square feet for each radiator. This in turn is equal to about 304 lineal feet of 1-inch pipe. Therefore the four radiators would be equal to about 1216 lineal feet of 1-inch pipe. Assume about 100 lineal feet of 1-inch pipe for the coil and again about 200 lineal feet for the 1-inch service line. Then 150 feet of ½-inch pipe for the returns would be equal to about 75 lineal feet of 1-inch pipe. The total would be about 1600 lineal feet of 1-inch pipe to be taken care of by the trap.

The capacity for drainage of a well known steam trap of ½-inch size is given by the makers as 1000 lineal feet of 1-inch pipe. Thus indications point toward too small a trap. Before changing the trap, however, I would change the ½-inch return pipe to 1 inch and reduce it to ½ inch at the trap. Then tap a ¼-inch hole in the top of the trap and put in a ¼-inch equalizing pipe. This I think will stop the trouble. Mr. Thomas would do well to read the article by C. E. Squiers on page 923 of the same number of POWER in regard to the equalizing pipe as this fits his case perfectly.

GEORGE H. HANDLEY.

Newburgh, N. Y.

While the layout of Mr. Thomas' heating system appears from the sketch to be good, I find that globe or check valves on the return side of the radiators greatly improve the control, and that an air valve on each radiator is essential. But these deficiencies are not the main cause of his troubles. It is all in the size of the pipes. Make the pipe from the boiler to the first radiator (from right to left) on the second floor 1½ inches. The reducing valve should also be of this size. Then 1¼-inch pipe should be used from the first radiator to the end and the branch to each radiator should be 1 inch. These sizes are more or less a guess as I do not know the capacity of the radiators.

The fact that only the radiators on the second floor are flooded after a few hours' run is due to the small return pipe. I have never seen a ½-inch return pipe in a well behaved gravity system.

If Mr. Thomas will substitute a ¾-inch pipe for his ½-inch return, he will find that the system will work much better, and especially so if the return is increased to 1 inch from the first floor down to the trap.

On the first floor the radiators do not give trouble from flooding because very likely the pressure in them is higher than that in the radiators on the upper floor, thus holding back the water that otherwise would flow from the upper radiators to the trap and leaving the return pipe free for their own circulation.

ALEX DOLPHIN.

Jamaica, N. Y.

Available Heat to Steam Boilers*

By T. B. Morley

According to the generally accepted methods of determining the thermal efficiency of steam boilers, methods supported by the approval and recommendation of such an influential body as the Institution of Civil Engineers, the efficiency is subject to the condition of the fuel and air supplied as regards moisture; that is to say, such an accidental extraneous circumstance as a few days of wet weather previous to the boiler trial is allowed to influence the apparent heat economy of the boiler. Surely this is a very undesirable state of affairs, and indicates some need for reconsideration of the manner in which efficiencies are calculated.

In the method of carrying out boiler trials, as recommended by the Institution of Civil Engineers, measurement of the humidity of the air supply is omitted; but, apart from that, the arrangement of the heat balance sheet for the boiler, and the effect of that arrangement on the value obtained for the thermal efficiency, is, in the opinion of the writer, at fault.

In the form of heat account employed, the heat value of the dried fuel is placed to the credit side, and on the debit side are the heat transferred to the water in the boiler and the various heat losses, comprising heat carried away by products of combustion, heat carried away by excess air, heat lost by incomplete combustion, heat lost by unburnt carbon in ash, heat lost in evaporating and in superheating moisture mixed with the fuel, and the balance of the account due to radiation, unmeasured losses and errors.

It is the contention of the writer that the item heat lost in evaporating and superheating moisture mixed with the fuel is placed on the wrong side of the account. It should really be deducted from the heat value of the dried fuel in order to find the heat actually available for utilization by the boiler, and, of course, it is only the available heat that should be credited to the boiler.

The true thermal efficiency, based upon the available heat, will be somewhat higher than the value as usually calculated, the amount of the difference depending upon the amount of the heat items due to moisture mixed with the fuel, and also, as will be seen later, to moisture in the air supplied to the furnace.

The true heat supplied to the furnace is that due to all the processes to which the material (fuel and moisture) placed on the grate could be subjected, so as to achieve complete combustion. Then the combustion would produce the entire calorific value of the combustible constituents; that is, the "heat value of the dried fuel." But it is impossible to avoid also heating the associated moisture, first as liquid, then evaporating it and then superheating it; and the requisite heat can only come from the burning fuel, so that even under ideal grate conditions the heat available for steam raising is less than that of the dried fuel.

The actually available heat is the heat of the proportion of dry fuel contained in the "fuel as fired," less the heat absorbed by the moisture during its heating, evaporation and superheating to fluegas temperature.

An item of heat loss sometimes included in the heat account (not in that recommended by the Institution of Civil Engineers) is that due to moisture derived from the combustion of hydrogen in the fuel, which moisture also passes away as steam in the flue gases. This heat is, however, on a different footing from that previously discussed, and need not be deducted from the heat value of the dried fuel. It is due to hydrogen inherent in the fuel used, whereas that due to wet fuel is the result of a quite arbitrary and accidental circumstance.

The following figures will show the difference in the two methods of calculation, and in their results in a typical case:

Suppose the fuel to be coal containing 12 per cent. of moisture (which is frequently the case), and that the calorific value of the dried coal is 13,000 B.t.u. per pound, and the heat usefully employed in steam raising 8600 B.t.u. per pound of fuel as fired, or 9800 B.t.u. per pound of dried fuel. Taking the boiler-room temperature as 70 degrees Fahrenheit, and the flue temperature as 600 degrees Fahrenheit, the heat in one pound of superheated steam in the flue gases is approximately 1300 B.t.u.; hence the heat used in heating, evaporating and superheating the moisture mixed with the fuel is

$$0.12 \times 1300 \textit{ B.t.u.} = 156 \textit{ B.t.u.}$$

per pound of fuel as fired, or

$$156 \div 0.88 = 177 \textit{ B.t.u.}$$

per pound of dried fuel.

According to the recommendations of the Institution of Civil Engineers, the heat account (dealing only with the items in question) would be as follows:

	B.t.u.	Per Cent.
Heat value of 1 lb. of dried fuel..	13,000	100
Heat transferred to water (per pound of dried fuel).....	9,800	75.3
Heat lost in evaporating and superheating moisture mixed with fuel.....	177	1.36

The true efficiency, taking the actually available heat as the basis of calculation, is

$$\frac{75.3}{100 - 1.36} \times 100 \textit{ per cent.} = 76.5 \textit{ per cent.}$$

and the true heat account (again only for the items in question) will be

	B.t.u.	Per Cent.
Heat value of 1 lb. of fuel as fired (=heat value of dry coal in 1 lb. of coal as fired — heat absorbed by moisture) = 0.88 × 13,000 — 156=	11,240	100
Heat transferred to water (per pound of fuel as fired).....	8,600	76.5

It will be noticed that in the latter case the heat quantities are all stated per pound of fuel as fired, instead of per pound of dried fuel.

The efficiency obtained in the usual way is thus rather more than 1 per cent. below the true value. The difference is small, especially when compared with the probable errors in a boiler trial; but there may easily be cases in which it would be greater, and, even though the error be small, that is no valid reason for adhering to a wrong principle.

Turning now to the question of moisture in the air supply, any moisture entering the furnace with the air should, for exactly similar reasons, be treated in the same way as moisture mixed with the fuel.

The effect of a moist air supply is not usually taken into account at all, but it may have a surprisingly great influence.

In certain boiler experiments recently reported to the Institution of Engineers and Shipbuilders in Scotland ("Experiments on the Efficiency of a Live Steam Feed Heater," by Prof. A. H. Gibson), the moisture carried into the furnace in the air supply amounted to no less than 0.34 pound per pound of dried coal; the heat required to convert it into the condition in which it reached the chimney would be about 3.4 per cent. of the heat of the dried fuel. Hence by regarding it as a loss instead of a necessary deduction from the otherwise available heat, the thermal efficiency of the boiler is stated as 3.5 per cent. less than it really is. Such a conclusion points to the necessity for measuring the humidity of the air supplied to a boiler whenever accurate results are desired.

It is strange that for so long engineers have tested boilers, given figures for their thermal economy and even based arguments as to the relative merits of different boilers on small differences of efficiency, when at the same time they have relied on efficiency values subject to influences so uncertain, so entirely unrelated to the design of the boilers themselves as the effects of wetness in the fuel and air supply, which means, in many cases, the effects of our variable weather conditions.

*Extracts from an article in *Engineering*.

Muffler explosions in a gasolene engine are due to misfiring, the unburned mixture being delivered into the hot exhaust passages where it is ignited. Misfiring may be caused by the exhaust valve being hung up or the stem being bent and preventing the valve from seating properly, by the mixture being too weak or by ignition trouble.

New Power House Equipment

What the inventor and the manufacturer are doing to save time and money in the engine room and power house. Engine room news

Siphon Water Softening and Purifying System

One type of water-softening and purifying system, manufactured by William B. Scaife & Sons Company, Pittsburg, Penn., is an automatic continuous system, known as the siphon system; its operation depending upon the action of the siphon. It is shown in the accompanying illustration.

The water entering the system flows into the siphon tank until a hight is reached sufficient to start a flow through the main siphon, which then continues to flow until the tank is emptied. When the main siphon begins to flow it starts the auxiliary siphons, which introduce the reagents into it during its period of flow. As soon as the tank from which the main siphon operates is emptied all siphons stop flowing until the tank refills to the point where it again starts the siphons flowing. The harmonious action of these siphons depends upon the head of water in the tank and not upon the rate of flow of the incoming water.

As the main siphon will always start and stop under the same conditions, the auxiliary or chemical-introducing siphon will always operate under the same conditions. The chemicals are, therefore, introduced in exact proportion, and in an exact amount to a certain definite amount of water determined by the strength of solution and the setting of the valve in the auxiliary or chemical siphon.

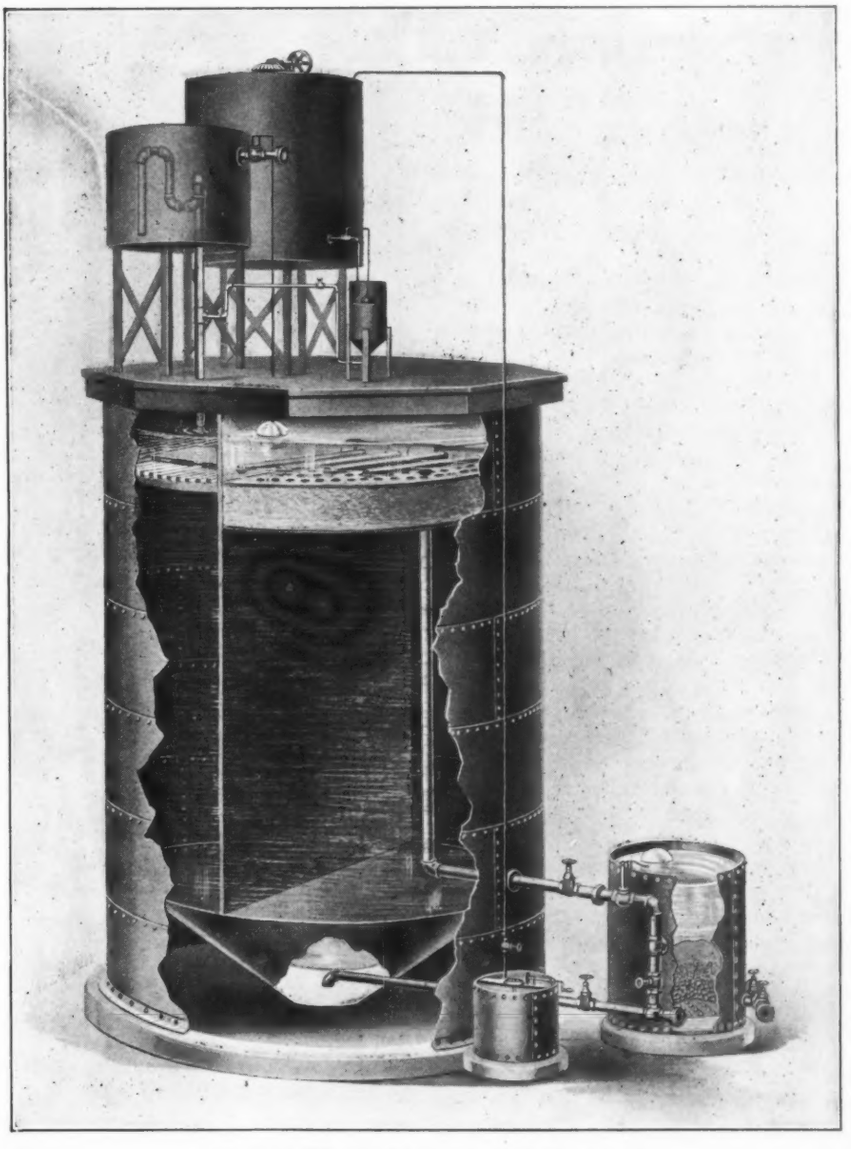
The chemical siphon is fed from a small constant-level solution tank that is connected with the main solution or solution-storage tank. The flow to the constant-level solution tank is controlled by a float to keep the head under which the chemical siphon is operated always the same. The conditions for the operation of the chemical siphon is, therefore, controlled only by the flow in the main siphon, which, in turn, is dependent only on the water entering the siphon tank.

After the mixture of water and reagents in the discharge pipe of the main siphon, the water and reagents are dashed against a baffle located below the water line in the reaction compartment of the treating and settling tank. This completely mixes the water and reagents.

The discharge from the siphon is deflected upward and outward, so that the delivery through the slatted partition into the reaction chamber is not directly from the siphon discharge, but by a difference of water level in the two compartments of the treating and settling tank.

As this movement of the water is intermittent and the discharge from the siphon is very rapid, the level of the water above the slatted partition becomes higher than it is at the same instant in the compartment over the filter, and exerts uniform pressure over the entire area of the reaction chamber and produces a movement corresponding to the difference in head on the entire volume of the settling compartment and through the whole area of the wood-fiber filter. There is little or no chance for dead spaces, as all of the water in the entire tank is moved simultaneously with the flow of water at each discharge of the siphon.

In order to prevent any possibility of



SIPHON WATER SOFTENER AND PURIFIER

short-circuits in the settling compartment, a collecting header is placed above the excelsior filter, the openings in which are so placed as to draw the water uniformly from all parts of the settling tank. From this header the water flows to the heater, boiler or wherever it is to be used.

If clear water is wanted, a mechanical gravity filter as shown in the illustration is furnished to remove any suspended matter left by the excelsior filter. Where it is desired to discharge the water at a hight, for instance, into an open heater, a mechanical pressure filter can be substituted for the gravity filter.

The reagents are dissolved in the reagent-mixing tank shown on the ground and by a steam-jet pump or any other means is delivered to the solution-storage tank, located on top of the tank, twice every 24 hours, or as often as may be desired, depending upon the conditions under which the system is operating.

It is sometimes desirable to make the system so that it can be operated from the ground, in which case a steam engine, electric motor or water motor can be used to lift the chemicals from the solution-storage tank located on the ground to the constant-level siphon feed tank. Any excess solution is returned to the solution-storage tank by an overflow.

The design can be modified to adapt it to a great variety of operating conditions, for the softening and clarification of any water for boiler feed or industrial uses.

The two monster White Star liners, the "Olympic" and the "Titanic," the former of which completed its first trip from England to New York in June, are each equipped with refrigerating machines of 85 tons daily capacity.

The Hackenberg Turbine

Probably more engineering attention is being devoted to the design of the steam turbine at the present time than has ever been given to any other prime mover, and among other designs which claim the notice of the engineer and the investor is the single-runner ten-stage turbine brought out by the Hackenberg Turbine Company, Flushing, N. Y.

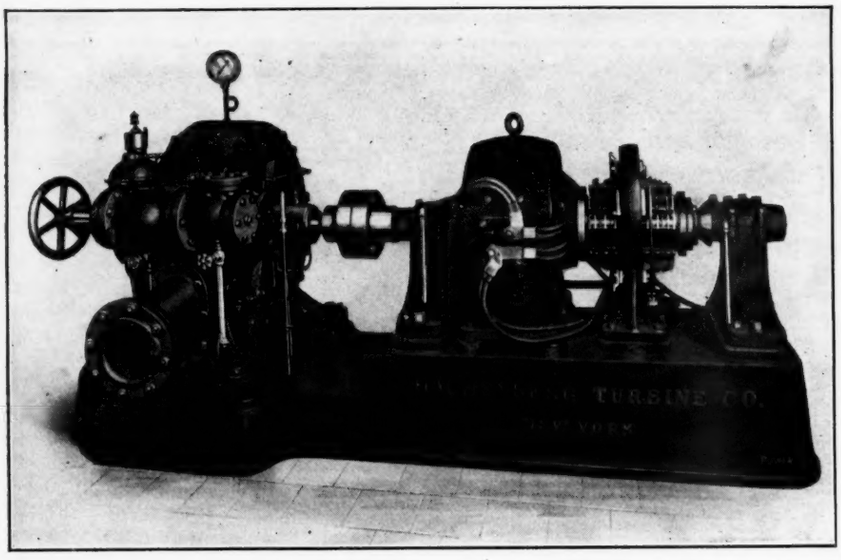


FIG. 1. TURBINE CONNECTED TO HIGH-SPEED GENERATOR

It is a compact multiple diametrical-flow turbine of ten stages. Five rings of vanes project from each side of a forged-steel disk, secured to the shaft. This constitutes the moving element, the vanes of which revolve between the fixed vanes projecting from the heads. The principle upon which this turbine is based is the use of the steam from the circumference inward to the center, thence outward to the circumference, whereby each ring of vanes receives the same steam twice in one revolution; one ring of vanes gives two stages and five rings of vanes a ten-stage machine. All these rings are secured to one disk, permitting small size and reduced cost of manufacture.

Steam enters through a number of nozzles from a chest which forms the upper half of the case. These nozzles, of uniform dimensions, are arranged side by side and supply steam to both sides of the rotor, preventing side thrust. The thrust bearing on the governor side of the turbine keeps the rotor in its proper position at all times and without friction.

The steam is partially expanded in the nozzles, and after leaving the vanes of the first moving ring is directed by the ring of guide vanes to the second ring of moving vanes and so on to the center. It then enters the center chest which allows no undue expansion, but guides the steam without contact around the shaft to each ring of vanes in the lower half and to the exhaust, always giving up energy and gaining velocity from one stage to the next. As the steam in its travel from top to bottom is deflected but little from a straight downward course, the turbine is kept perfectly drained at all times and it is not necessary to heat it up before starting.

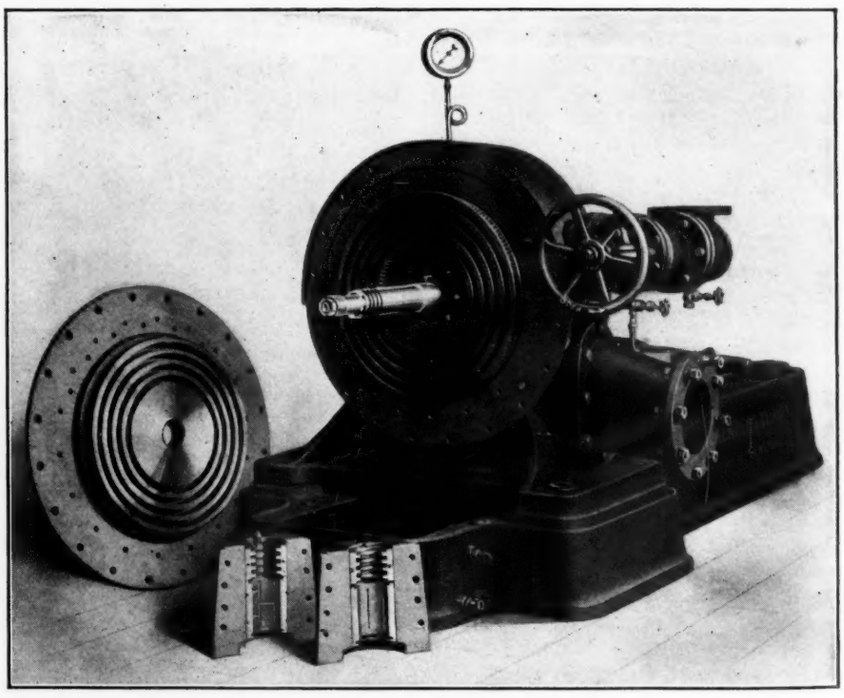


FIG. 2. TURBINE PARTIALLY DISMOUNTED

The moving vanes as well as the guide vanes are secured to their respective disks in a manner insuring rigidity and

durability and are so assembled as to permit each machine to be adapted to the condition under which it is to be used as to steam pressure, rotative speed, etc., without making any changes in its general construction. This means that the same castings can be used for a large range of units and that the efficiency is very nearly uniform for all units.

Loss from eddy currents and the passage of steam from one stage to the next and around the ends of the stationary and moving vanes is reduced to a minimum by the small clearance of 1/64 inch on the side and 1/32 inch between rings. Forced lubrication is provided for by a pump attached to the governor shaft which takes the oil from a reservoir cast in the base and distributes it to all bearings from which it flows by gravity back to the reservoir and is used over continuously.

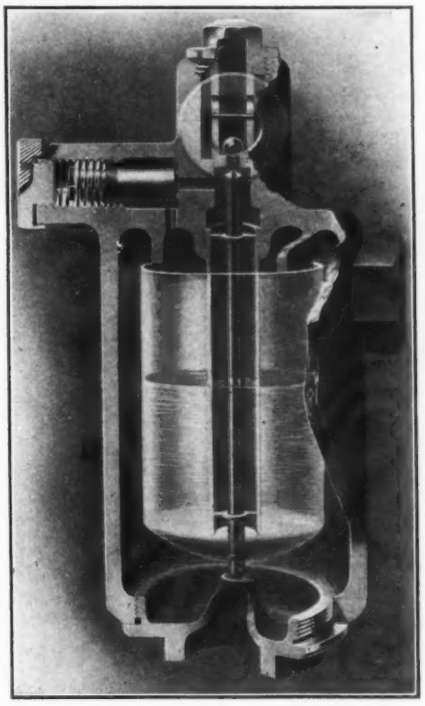
Speed is controlled within 1 per cent. between the limits of no load and full load by a specially designed inclosed fly-ball governor.

A reversing marine unit of 6 horsepower has been designed which will change from full speed forward to full speed backward in five seconds.

Fig. 1 shows a turbine directly connected to a generator designed for high rotative speed. Fig. 2 is a view of the same machine partially dismantled, showing one set each of the moving and stationary rings, the central guiding chest and the thrust bearing.

Stickle Thermic Valve

The Stickle thermic valve is made with an open float with an automatic thermostat bypass at the top of the open float, releasing the air through the main valve, providing very large air passage, making it possible to release the air from the radiator or coil very rapidly.



SECTION OF THERMIC VALVE

bypass at the top having an adjustable valve-seat casing that is screwed in from the top.

When the air and condensation are exhausted, steam closes the thermostat bypass and the water is forced or drawn out of the open float by a vacuum. Then the float immediately rises, closing the discharge pump, except the small groove in the valve, which permits a slight continuous discharge, thus releasing the air as fast as it accumulates. When the bucket or open float again fills, it drops, and opens wide the valve. When the accumulated condensation has been discharged, the open float becomes light and rises again, closing the valve and automatically preventing any escape of steam into the return line.

A water seal is maintained at all times in the bottom of the bucket. It floats with fully ½ inch of water in it, sealing the discharge pipe. This seal is downward and steam will not pass downward through water; consequently, no steam can be blown through by gravity or drawn through by vacuum.

This valve is manufactured by the Open Coil Heater and Purifier Company, 502 South Pennsylvania street, Indianapolis, Ind.

Solderall Paste Solder

Recently a new kind of paste solder, known as Solderall, has been placed on the market. It is put up in a collapsible tube and all that is necessary for its effective use is to scrape off the surface

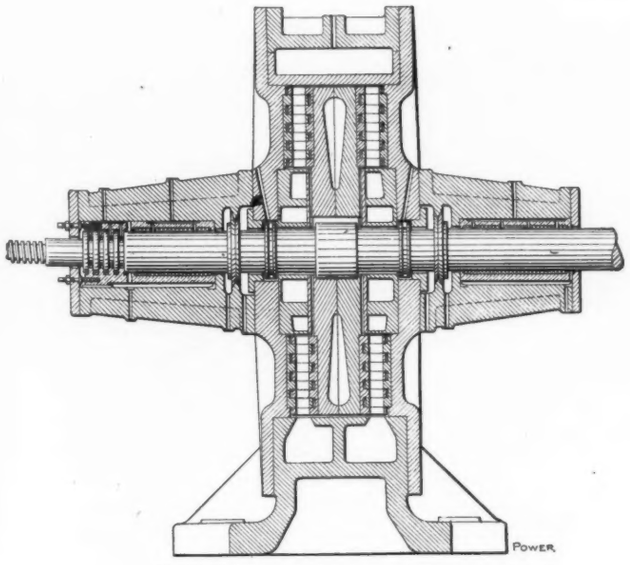


FIG. 3. LONGITUDINAL CROSS-SECTION

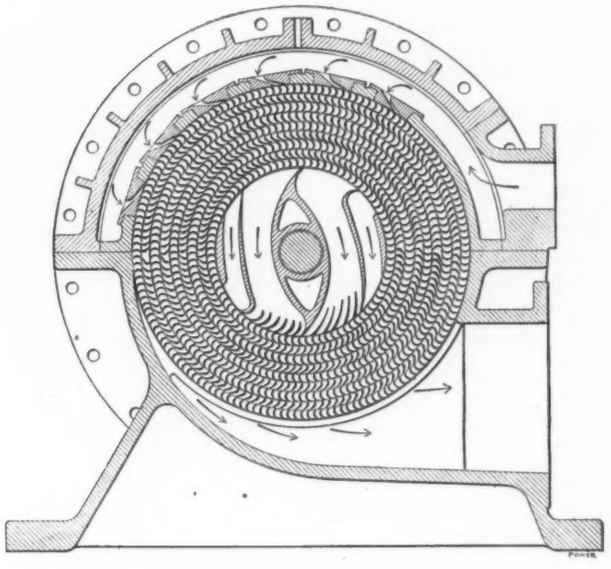


FIG. 4. TRANSVERSE SECTION THROUGH

In the longitudinal section (Fig. 3) the double rows of vanes are shown, and in the transverse section (Fig. 4) the path of the steam from the chest, through the nozzles, moving and stationary vanes, the central guide box and out, is plainly seen. The arrows indicate the direction of flow.

The sectional view shows a casing in which is an open float to which a valve rod is attached. The rod is guided by a tube extending downward into the open float. A ring cast integral with the top extending down into the top of the open float to prevent the valve rod from bending. There is an automatic air-valve

of the part to be soldered a little with a knife, squeeze some of the soldering paste on and apply a match, candle or torch. When the paste becomes hot it fuses and solders in the same manner as the old-style soldering stick. It is made by the H. W. Johns-Manville Company, 100 William street, New York City.

Special Design of Relief Valve

This relief valve has been designed to be installed in an exhaust pipe and opens whenever the stipulated pressure per square inch for which the springs have been set is exceeded.

In order to economize head room, the springs are placed horizontal, thus permitting the valve to be placed in a pipe line close to a ceiling or other obstruction.

The springs are adjustable to within 5 per cent. above and below the pressure stipulated.

The valve is constructed with an automatic noiseless piston which prevents hammering. The disk is centrally guided to place on its seat and is carefully adjusted and well ground in. These features in addition to the balanced piston prevent hammering. The valve automatically opens and closes, and there is also means for locking the valve permanently open.

The exhaust steam enters the body on the under-seat side and passes through small holes in the stationary piston *B*, Fig. 2, and passing into the cylinder acts as a very efficient dashpot, whereby the bell *C* floats on the exhaust steam.

This valve is fitted to seat on the valve seat of the valve body, but when used on the exhaust lines from turbines where there is no lubricant in the steam, it is recommended that it be fitted with a bronze seat and water seal.

The horizontal spring mechanism, as per Fig. 1, can be applied to the angle, globe, downward discharge through passage, downward discharge side inlet, but not to the vertical.

This valve is manufactured by the Schutte & Koerting Company, Thompson and Twelfth streets, Philadelphia, Penn.

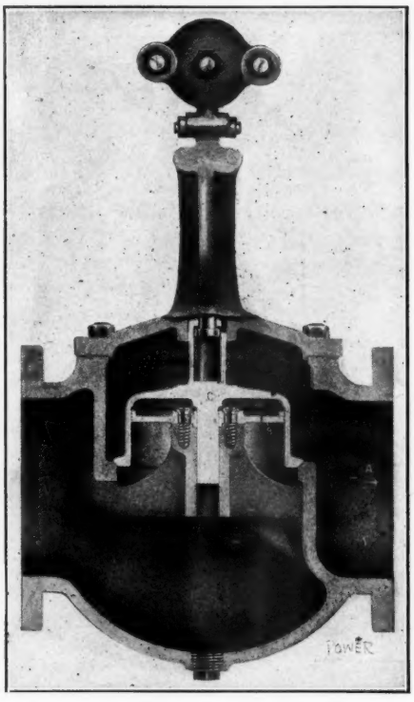


FIG. 2. SECTIONAL VIEW OF VALVE

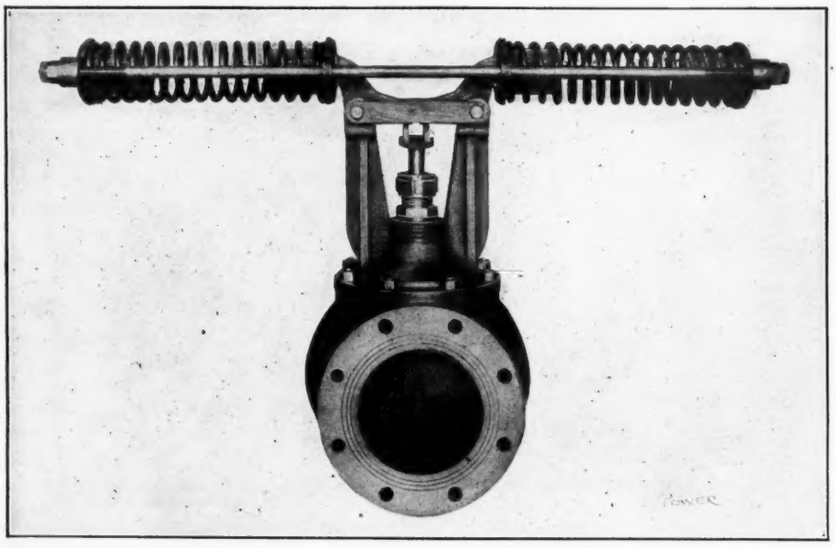


FIG. 1. SPECIAL DESIGN OF RELIEF VALVE

SOCIETY NOTES

The Ohio Electric Light Association will hold its seventeenth annual convention at Cedar Point, O., on July 25 to 28. A number of interesting papers are to be read and special attention has been given to the entertainment of those attending the convention.

Local Union No. 20, International Union of Steam Engineers, and the Eccentric Association of Engineers, No. 1 of New York City, recently amalgamated for the benefit of each of the organizations. The election of officers on Saturday evening, July 8, resulted in the following selections for the ensuing year: P. M. Cusack, president; P. Stratford, vice-president; P. J. Horan, recording secretary; W. A. Mooney, financial secretary; Bernard Cassidy, treasurer; Alfred Schmidt, conductor; Isaac Swuner, guard; P. J. Connolly, business agent; P. Gilleaney, Edward J. Hanley, R. Quann, trustees; Frank McDougal, Joseph Kavanagh and P. Phillips, auditors. The combined organization will be known as Local Union No. 20, International Union of Steam Engineers. During the evening speeches were delivered by Matt Comerford, W. Keogh, M. Murphy and other prominent members. There was an entertainment, and refreshments were served.

NEW PUBLICATION

The McGraw-Hill Book Company announces an edition in cloth of Frederick W. Taylor's "Shop Management." This is a reprint of Mr. Taylor's paper delivered before the American Society of Mechanical Engineers in 1903. It embodies the essentials and fundamentals of Mr. Taylor's principles of efficiency, and has for several years been the standard work on the subject. It is now available in permanent binding for the first time. Price, $1.50 net.

BOOKS RECEIVED

MARINE ENGINE DESIGN. By Edward M. Bragg. D. Van Nostrand Company, New York. Cloth; 172 pages, 5x8 inches; illustrated; indexed. Price, $2.

PRINCIPLES OF INDUSTRIAL ENGINEERING. By Charles B. Going. McGraw-Hill Book Company, New York. Cloth; 174 pages, 6x9 inches; indexed. Price, $2.

COLD STORAGE, HEATING AND VENTILATING ON BOARD SHIP. By Sydney F. Walker. D. Van Nostrand Company, New York. Cloth; 269 pages, 5x8 inches; 71 illustrations; indexed. Price, $2.

PRACTICAL APPLIED ELECTRICITY. By David Penn Moreton. The Reilly & Britton Company, Chicago, Ill. Flexible leather; 438 pages, 4½x7 inches; 323 illustrations; 20 full-page tables; indexed. Price, $2.

PERSONAL

N. B. Ayers, a member of the American Society of Mechanical Engineers, has resigned as chief engineer of the Dayton Power and Light Company and organized the Ayers Engineering Company, to handle power-plant engineering. Address, Conover building, Dayton, O.

Moments with the Ad. Editor

A department for subscribers edited by the advertising service department of Power

THE 4th of July this year was the 100th anniversary of New York's famous old City Hall, which is still doing business at the old stand, at the end of Brooklyn Bridge.

One of the most interesting things one remembers about this noted building is that the city fathers who built it had the north side finished with brick instead of stone because they thought the building was so far up-town that no one would ever see its north side.

Now, of course, the City Hall is considered way down town. It is many miles south of the great residential sections.

What an eloquent story of American progress and growth!

Think what has happened in the metropolis, in the country, in *your* profession in the last hundred years.

And think again how much faster things have happened in the last ten or fifteen years than in all the 85 or 90 years previous.

For this greater speed of progress in recent years perhaps no one factor has been more potent than Modern Advertising.

It was advertising that made Manhattan real estate boom.

It was advertising that made New York grow beyond the census man's estimates.

It was advertising that helped to build New York's commercial supremacy.

And it is advertising that has done so much to make your profession one of the largest and most important in the world today.

As one employer said recently, "Show me the engineer who reads, intelligently, the ads in his profession's paper and I'll show you one that's going to rise, dead sure."

One reason why is—if advertising isn't up-to-date, progressive and helpful to the reader, it's useless. And the modern advertiser isn't spending his good money on anything that's useless these days.

Are you a faithful follower of the ads?

BUSINESS ITEMS

Owing to the rapid growth and increase of business of the Paul B. Huyette Company, Inc., manufacturer of the "P. B. H." water gage, "P. B. H." gage cock and other steam specialties, it will remove on or about August 31 from its present five-room quarters in the Betz building, Philadelphia, to the building at the southeast corner of Eighteenth and Market streets, Philadelphia, where it will occupy the entire third and fourth floors, which are about four times as large as its present quarters.

Harry J. Marks will hereafter act as the sole agent, in the Metropolitan district, for the American Engine Company, Bound Brook, N. J. Mr. Marks has installed a large number of American-Ball engines, including both simple engines and the American-Ball angle compound engine, under a great variety of conditions and for different services. Mr. Marks will be glad to furnish data and information relating to power plants for central stations, office buildings, apartment houses, hotels, factories, hospitals, etc., and in regard to reduction of steam consumption, floor space, noise, vibration, etc. He will give special attention to the installation of these engines in connection with exhaust-steam heating systems. His offices are located at 90 West street, New York, Telephone Cortland 4810.

NEW EQUIPMENT

Blyth, Ont., will extend its electric-light plant.

Fitchburg, Mass., will extend its sewer system.

Cambridge, Vt., will install a new water system.

The Forest City Electric Company, Cleveland, Ohio, will make changes in its plant.

The Nazareth (Penn.) Cement Company is overhauling and enlarging its power plant.

The Saginaw (Mich.) water board will install two engines at the west side waterworks.

The installation of an electric-light plant at Orangeville, Ill., is said to be under consideration.

The citizens of Grove, Okla., voted to issue $35,000 bonds for electric-light plant and waterworks.

The city council, Fort Collins, Colo., is preparing to build a municipal electric-light and power plant.

Baraga, Mich., is considering the installation of an electric-light and water plant to cost $35,000.

The Malad (Ida.) Electric Company is planning to install an electric-lighting plant at Caldwell, Ida.

The Spokane Falls Gas Light Company, Spokane, Wash., is planning the erection of a new $500,000 plant.

Lawrenceville, Va., will vote on issuing $50,000 bonds for waterworks, electric-light plant and sewer system.

The Shawinigan Water and Power Company is erecting a large new power house at Shawinigan Falls, Quebec.

Pawhuska, Okla., will vote on issuance of $10,000 bonds for improvements and extensions to its electric-light plant.

The Savannah Power Company, Anderson, S. C., is said to be contemplating installing an auxiliary steam power plant.

The Mt. Hood Railway, Light and Power Company, Portland, Ore., will build a new power plant at Sulphur Springs.

The Northern California Power Company, Sacramento, Cal., is planning the erection of a new substation at Kennett, Cal.

The Hillsboro (Ill.) Electric Light and Power Company has awarded contract for the construction of a new power house.

Brandon, Manitoba, will electrify its present steam waterworks pumping plant and will add two 2,000,000 variable-speed pumps.

Sixty-five thousand dollars bonds have been voted to increase output of the municipal electric-light plant at Hardwick, Vt.

Andover, Ohio, will receive bids for waterworks machinery. Specifications can be had of J. W. Cook, clerk, board of public affairs.

The Memorial Hospital, Belmont street, Worcester, Mass., is contemplating installing electric motors for kitchen and laundry service.

The Farmers Ice and Canning Company, Tampa, Fla., will construct a new ice, cold-storage and canning plant to replace the one burned.

The boiler house and several other buildings of the Marietta (Ohio) Torpedo Company were destroyed by an explosion. Loss, $30,000.

The Electric Water Company, Bakersfield, Cal., is planning the installation of a waterworks system at East Bakersfield, to cost $160,000.

The Harshaw, Fuller & Goodwin Company, Elyria, Ohio, will erect another building at its chemical works. An electric-light plant will be installed.

Allaire, Woodward & Co., 110 Main street, Peoria, Ill., are in the market for an engine of about 350 horsepower. A. E. Reynolds, chief engineer.

The Industries Light and Power Company, Alexander City, Ala., recently formed, is said to be contemplating the construction of a dam and power plant.

The Portland (Ore.) Railway, Light and Power Company is having plans prepared for a new power house to be erected on Lincoln street, to cost $100,000.

Fire destroyed power house of the Commonwealth Power Company, Trowbridge, Mich., causing a loss of about $100,000. It is said the plant will be rebuilt.

The city of Cleveland, Ohio, has under consideration the overhauling of the pumps at the Old Division Street pumping station and using same for fire service.

The board of supervisors, Los Angeles, Cal., will receive bids until August for two engine generator sets for the Hall of Records. H. J. Lelande, county clerk.

The Hancock County Electric Company, New Cumberland, W. Va., has been incorporated with $12,000 capital to construct a power plant by John F. Flood, H. E. Armstrong, N. D. Miller, etc.

The Beach City Electric Light and Power Company, Beach City, Ohio, has been incorporated with $35,000 capital by A. H. Elliott, Iva Arnold, W. H. Smith, etc. Will erect electric power plant.

The Gary, Hobart & Eastern Traction Company, Gary, Ind., has been incorporated with $125,000 capital to construct an electric road from Gary to Valparaiso. Incorporators, W. H. Clinton, A. Z. Olson, A. J. Smith, etc.

E. D. Johnston, Connersville, Ind., is preparing to erect three electrical power plants, one to occupy the old waterworks site, another to be built at the south end of the city and a small reserve plant between the two larger plants.

The Auglaize Power Company, Toledo, Ohio, has been incorporated with $1,000,000 capital to furnish hydroelectric power to serve eight counties. One plant will be erected on the Maumee river, near Toledo and another on the Auglaize river, at Defiance. Jas. M. Ashley is president.

NEW CATALOGS

Locke Regulator Company, Salem, Mass. Catalog N. Damper regulators, steam pressure regulators, reducing valves, pump regulators, etc. Illustrated, 56 pages, 6x9 inches.

International Steam Pump Company, 115 Broadway, New York. Bulletin W-176A. Worthington Type D centrifugal pumps for low-head service. Illustrated, 12 pages, 6x9 inches. Bulletin W-185. Worthington centrifugal house and sump pumps. Illustrated, 8 pages, 6x9 inches.

HELP WANTED

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

WANTED—Thoroughly competent steam specialty salesman; one that can sell high-grade goods. Address "M. M. Co.," POWER.

WANTED—For Pittsburg and St. Louis territory, high-grade representatives to sell first-class high-speed engine on commission basis. Preferably, representatives who are handling power plant equipment. Box 458, POWER.

AN ENGINEER in each town to sell the best rocking grate for steam boilers. Write Martin Grate Co., 281 Dearborn Street, Chicago.

AGENTS WANTED for first-class steam specialty in use throughout United States. Address C. S. Wood, 410 S. 15th St., Philadelphia, Penn.

WANTED—Salesmen traveling among engineers to sell Ideal metallic packing on commission. Ideal Metallic Packing Co., South Stillwater, Minn.

WANTED—Chief engineer to take charge of power plant, three buckeye engines and low pressure turbine, total 2000 horsepower; state wages wanted. Box 463, POWER.

WANTED—Salesmen or engineers who can sell grates, to represent the Shear Klean rocking and shearing grates. Address Chicago Grate Company, Monadnock Block, Chicago, Ill.

THE VULCAN SOOT CLEANER offers an exceptional opportunity for power specialty salesmen. For further particulars address G. L. Simonds & Co., 802 Steinway Bldg., Chicago, Ill.

WANTED—An engineer in each city as agent for a high class water-back Scotch boiler, the most economical steam generator known to the trade. Kingsford Foundry & Machine Works, Oswego, N. Y.

SALESMEN to sell new and improved boiler compound in the States of Ohio, Indiana, Illinois and Wisconsin; good salary and expenses to competent men; in making application give age and state experience. Address "Boiler Compound," Box 456, POWER.

SITUATIONS WANTED

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

POSITION WANTED by A-1 engineer and electrician as engineer of medium size l'ght and water works; 20 years' experience; sober, married; indicator, tools, A-1 references; moderate salary. "E. Z. E.," Rockdale, Tenn.

POSITION WANTED by married man, sober and reliable of 12 years' experience, understands alternating and direct current electricity and ice machinery; can give good reference. Address Geo. Abel, Ness City, Kan.

TECHNICAL MAN, 34, married, 13 years' experience, power, light, telephone, construction and operation, want connection as electrical engineer or superintendent, light or power plant; good business ability; prefer West or South; would consider foreign country. Box 433, POWER.

MECHANICAL ENGINEER, 34, American, married, 10 years' experience, Latin-American countries, designing, construction testing and operating gas power plants, open for engagement as superintendent of light or power plant, mining or milling work, business ability; can represent machinery house; correspondence in Spanish, French and German; prefer foreign countries, Latin-American or Hawaiian Islands. Box 462, POWER.

MISCELLANEOUS

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

PATENTS. C. L. Parker, Patent Attorney, ex-examiner Patent Office, 904 G St., Washington, D. C. Write for Inventor's Handbook.

ROPES SPLICED and repaired, cable, transmission, elevator, wire or manila; men sent anywhere. Shatte & Aicher, 207 Taaffe Place, Brooklyn, N. Y. 'Phone 3287 Prospect.

EVERY ENGINEER should be posted regarding the new system of vacuum heating installed without payment of royalty; I have valuable information; write today. T. L. Reeder, 1417 W. Jackson Blvd., Chicago, Ill.

FOR SALE

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

FOR SALE—20x48 Wheelock engine and two 72"x18' high pressure tubular boilers in good condition cheap. Address "Engineer," Box 2, Station A, Cincinnati, Ohio.

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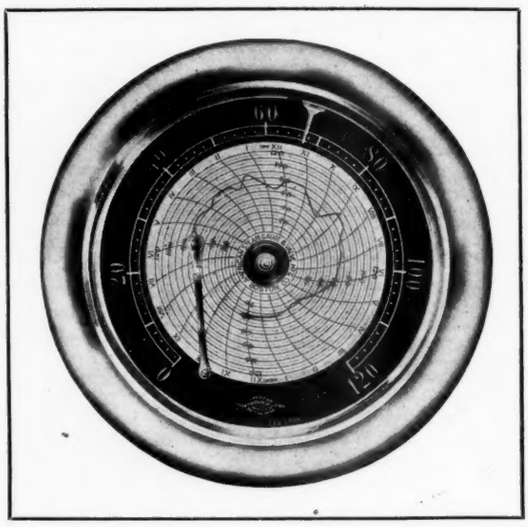
A Tireless Watchman

That

Guards The Coal Pile



The American Pressure And Recording Gauge

Makes undetected coal wastes impossible.

Shows the pressure carried on the boiler every hour of the day and night, 365 days in the year, and forms a continual record of the work done in the boiler room.

Marks the fluctuations in pressure, shows if the fireman has neglected his duty and when, tells at a glance if your coal is being used economically. Furthermore it supplies visible proof from which you can accurately determine the value of the men responsible for results in your boiler room.

Every plant, small and large, should have one of these American Pressure and Recording Gauges, either in the manager's office or the engine room.

Guards against waste of fuel and quickly pays for itself.

May we send you full particulars of this and our other power plant specialties?

American Steam Gauge & Valve Mfg. Co.

Boston, Mass.

ATLANTA	CHICAGO	NEW YORK	PITTSBURG	MONTREAL
525 Candler Bldg.	130 No. Jefferson St.	30 Church St.	Jenkins Arcade Bldg.	444 St. James St.

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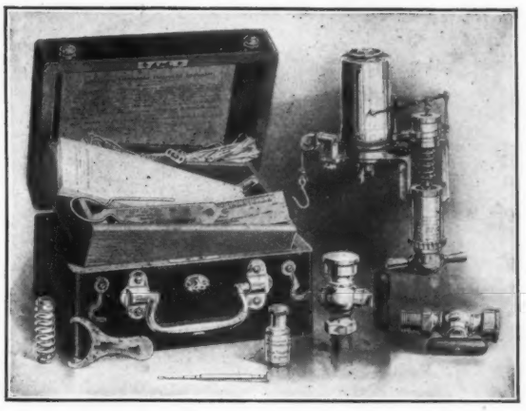
First Aid To Engineers

Who Are

Ambitious To Advance



The American-Thompson Improved Indicator

Gives the engineer confidence in himself—shows him what's going on inside the cylinder.

Enables him to guard against steam leaks past piston and valves.

He can also prove that his engine is being run economically, and that he is getting the most out of the engine at least cost.

Unless you can prove to the manager that you are complete master of the engine, are saving him money on coal and repairs —you can't expect promotion.

You can afford to buy an American-Thompson. The price of the outfit shown is $55.00, and the terms are $5.00 down, $5.00 monthly.

Send first payment today with reference, and we'll ship your outfit at once.

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Boiler Water Skimmers

Buckeye Boiler Skimmer Co..116

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Allis-Chalmers Co..... 91
American Well Works..... 106
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Ohio Brass Co..... 91
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OIL BUGABOO EXHUMED

The oil bugaboo is dragged out and exhibited from time to time. But he is not worrying the thousands of competent engineers who have installed COCHRANE OIL SEPARATORS OR COCHRANE HEATERS. COCHRANE SEPARATORS now satisfactorily protect something like 10,000,000 H.P. capacity of boilers from oil, and we will gladly refer you to the plants where they are doing it.

It was the COCHRANE OIL SEPARATOR that made people want open heaters. The COCHRANE was the first oil separator to give commercially satisfactory and successful results. It is the separator which today stands the chemist's tests. Some time ago one of the largest locomotive shops in the country installed a COCHRANE HEATER equipped with a COCHRANE OIL SEPARATOR, and their chemist reports the results obtained by it as follows:

"The water was flowing freely and therefore the sample should show the degree of separation of the oil from the water in these heaters.

"Because of the very minute quantity of oil, the sample was agitated from time to time for two days with chloroform, which we thought would be the best solvent to use and it was allowed to evaporate below its boiling point to prevent possible loss of oil."

This report explains one of the reasons why this locomotive company has put in three more COCHRANES, aggregating nearly 10,000 H.P., and why another locomotive builder has installed nine COCHRANE HEATERS of nearly 20,000 H.P. combined capacity.

The following guarantee assures equally satisfactory results to every purchaser of a COCHRANE OIL SEPARATOR OR A COCHRANE OPEN HEATER.

That they will (in either the Horizontal or Vertical form) deliver exhaust steam so thoroughly purified from grease and cylinder oil that this steam can safely be used for heating water by actual contact, for boiler feed, dye house and other purposes; or that this steam, when condensed, will be entirely suitable for similar purposes.

COCHRANE SEPARATORS keep the oil out of your heating or drying systems, closed or open heaters, or surface condensers. Send us particulars so that we can tell you just how to do it. A great deal depends on the "how" and our extensive experience has made us experts.

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